7. Western Canal Water District (2020 AWMP Update)

This section of the Feather River Regional AWMP contains plan components specific to Western Canal Water District (WCWD).

7.1 Contents

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Abbreviations

AB 1668	Assembly Bill 1668
AB	Assembly Bill
AWMC	Agricultural Water Management Council
AWMP or Plan	Agricultural Water Management Plan
BBGM	Butte Basin Groundwater Model
BMOs	Basin Management Objectives
BWD	Butte Water District
BWGWD	Biggs – West Gridley Water District
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	California Code of Regulations
CCUF	Crop Consumptive Use Fraction
CWC or Code	California Water Code
DF	Delivery Fraction
DMP	Drought Management Plan
DWR	California Department of Water Resources
ET	Crop evapotranspiration
ET_{aw}	ET derived from applied water
Et_o	Reference Evapotranspiration
Et_{pr}	ET derived from precipitation
EWMPs	Efficient Water Management Practices
FRRAWMP	Feather River Regional AWMP
FWD	Feather Water District
GHMWC	Garden Highway Mutual Water Company
GMP	Groundwater Management Plan
GSA	Groundwater Sustainability Agency
GSPs	Groundwater Sustainability Plans

IDC	Demand Calculator
ILRP	Irrigated Lands Regulatory Program
ITRC	Irrigation Training and Research Center
IWFM	Integrated Water Flow Model
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
PG&E	Pacific Gas and Electric Company
PMWC	Plumas Mutual Water Company
RID	Richvale Irrigation District
SBx7-7	Water Conservation Act of 2009
SEBAL	Surface Energy Balance Algorithm for Land
SEWD	Sutter Extension Water District
SGMA	Sustainable Groundwater Management Act of 2014
SWSF	Surface Water Supply Fraction
Tailwater	Surface runoff of applied water
TMWC	Tudor Mutual Water Company
WCWD	Western Canal Water District
WIS	Water Information System
WMF	Water Management Fraction
WUE	Water Use Efficiency
WMO	Water Management Objectives

7.2 Introduction

This Agricultural Water Management Plan (AWMP or Plan) has been prepared by Western Canal Water District (WCWD or District) in accordance with the requirements of the Water Conservation Act of 2009 (SBx7-7), the 2018 Water Management Planning Legislation (Assembly Bill 1668, or AB 1668), and Agricultural Water Measurement Requirements under Title 23 of the California Code of Regulations (CCR), §597 *et seq.*, 2011.

In 2009, SBx7-7 modified Division 6 of the California Water Code (CWC or Code), adding Part 2.55 (commencing with §10608) and replacing Part 2.8 (commencing with §10800), with the overarching goal of improving water use efficiency. Among its provisions, SBx7-7 allowed the California Department of Water Resources (DWR) to update the efficient water management practices (EWMPs) that suppliers must implement[1], and led to the passage of agricultural water measurement regulations. SBx7-7 also required agricultural water suppliers to prepare and adopt an updated AWMP, as set forth in the CWC and the California Code of Regulations (CCR), every five years, beginning with a Plan adopted on or before December 31, 2012.

AB 1668 modifies Water Code §531.10 *et seq.* and Water Code §10820 *et seq.* to address water conservation issues more adequately and to improve the management and evaluation of agricultural water suppliers' systems. Specifically, AB 1668 requires updated AWMPs to:

(1) Include an annual water budget (CWC §10826(c)),
(2) identify water management objectives (CWC §10826(f)),
(3) quantify water use efficiency (CWC §10826(h)), and
(4) revise the supplier's Drought Plan to describe both drought resilience planning and drought response planning (CWC §10826.2).

AB 1668 also modifies AWMP submittal and compliance requirements, requiring the updated AWMP to be submitted to DWR on or before April 1, 2021 (no later than 30 days after adoption), and thereafter on or before April 1 in the years ending in six and one.

The main resources used to develop this 2020 AWMP were the CWC itself, the draft 2020 AWMP Guidebook, and the relevant sections of the CCR. A cross-reference table is provided on the following pages that identifies the location(s) in the AWMP where each applicable requirement of SBx7-7 and AB 1668, and the corresponding sections of the CWC and CCR, is addressed. This cross-reference is intended to support efficient review of the AWMP to verify compliance with the Law.

[1] Critical EWMPs must be implemented by all agricultural water suppliers. Conditional EWMPs must be implemented if they are locally cost-effective and technically feasible.

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7.3 AWMP Checklist

Table 7.1 provides a cross-reference of the requirements of the California Water Code (CWC) to the AWMP sections contained herein.

Table 7.1. Cross Reference Table of WCWD 2020 AWMP to Relevant Sections of the California Water Code.

AWMP Section	AWMP Guidebook Location	Description	Water Code Section (or as identified)
II.7.2, II.7.4	1.4	AWMP Required?	10820, 10608.12
II.7.4.1, II.7.5.2	1.4	At least 25,000 irrigated acres	10853
N/A	1.4	10,000 to 25,000 acres and funding provided	10853
II.7.2, II.7.4, II.7.10.1	1.4	April 1, 2021 update	10820 (a)
II.7.2, II.7.4, II.7.10.1	1.4 A.2	**Added to the Water Code:** <u>Added to the Water Code: AWMP submitted to DWR no later than 30 days after adoption; AWMP submitted electronically</u>	**New to the Water Code:** <u>10820(a)(2)(B)</u>
II.7.2, II.7.4	1.4 B	5-year cycle update	10820 (a)
N/A	1.4 B	New agricultural water supplier after December 31, 2012 - AWMP prepared and adopted within 1 year	10820 (b)
N/A	1.6, 5	USBR water management/conservation plan:	10828(a)
N/A	1.6, 5.1	Adopted and submitted to USBR within the previous four years, AND	10828(a)(1)
N/A	1.6, 5.1	The USBR has accepted the water management/conservation plan as adequate	10828(a)(2)
I, II.7	1.4 B	UWMP or participation in area wide, regional, watershed, or basin wide water management planning: does the plan meet requirements of SB X7-7 2.8	10829
II.7.9.1, II.7.4.3, II.7.6.3	3.1A	Description of previous water management activities	10826(d)

AWMP Section	AWMP Guidebook Location	Description	Water Code Section (or as identified)
II.7.4, II.7.10.1	3.1 B.1	Was each city or county within which supplier provides water supplies notified that the agricultural water supplier will be preparing or amending a plan?	10821(a)
II.7.4, II.7.10.1	3.2 B.2	Was the proposed plan available for public inspection prior to plan adoption?	10841
II.7.4, II.7.10.1	3.1 B.2	Publicly-owned supplier: Prior to the hearing, was the notice of the time and place of hearing published within the jurisdiction of the publicly owned agricultural water supplier in accordance with Government Code 6066?	10841
II.7.4, II.7.10.1	3.1 B.2	14 days notification for public hearing	GC 6066
II.7.4, II.7.10.1	3.1 B.2	Two publications in newspaper within those 14 days	GC 6066
II.7.4, II.7.10.1	3.1 B.2	At least 5 days between publications? (not including publication date)	GC 6066
N/A	3.1 B.2	Privately-owned supplier: was equivalent notice within its service area and reasonably equivalent opportunity that would otherwise be afforded through a public hearing process provided?	10841
II.7.4, II.7.10.1	3.1 C.1	After hearing/equivalent notice, was the plan adopted as prepared or as modified during or after the hearing?	10841
II.7.4, II.7.10.1	3.1 C.2	Was a copy of the AWMP, amendments, or changes, submitted to the entities below, no later than 30 days after the adoption?	10843(a)
II.7.4, II.7.10.1	3.1 C.2	The department.	10843(b)(1)
II.7.4, II.7.10.1	3.1 C.2	Any city, county, or city and county within which the agricultural water supplier provides water supplies.	10843(b)(2)

AWMP Section	AWMP Guidebook Location	Description	Water Code Section (or as identified)
II.7.4, II.7.10.1	3.1 C.2	Any groundwater management entity within which jurisdiction the agricultural water supplier extracts or provides water supplies.	10843(b)(3)
II.7.4, II.7.10.1	3.1 C.3	Adopted AWMP availability	10844
II.7.4, II.7.10.1	3.1 C.3	Was the AWMP available for public review on the agricultural water supplier's Internet Web site within 30 days of adoption?	10844(a)
N/A	3.1 C.3	If no Internet Web site, was an electronic copy of the AWMP submitted to DWR within 30 days of adoption?	10844(b)
II.7.9	3.1 D.1	Implement the AWMP in accordance with the schedule set forth in its plan, as determined by the governing body of the agricultural water supplier.	10842
II.7.5	3.3	Description of the agricultural water supplier and service area including:	10826(a)
II.7.5.2	3.3 A.1	Size of the service area.	10826(a)(1)
II.7.5.2, II.7.5.3	3.3 A.2	Location of the service area and its water management facilities.	10826(a)(2)
II.7.5.4	3.3 A.3	Terrain and soils.	10826(a)(3)
II.7.5.5	3.3 A.4	Climate.	10826(a)(4)
II.7.5.6, II.7.10.2	3.3 B.1	Operating rules and regulations.	10826(a)(5)
II.7.5.7, II.7.10.3	3.3 B.2	Water delivery measurements or calculations.	10826(a)(6)
II.7.5.8	3.3 B.3	Water rate schedules and billing.	10826(a)(7)
II.7.5.9, II.7.10.5	3.3 B.4	Water shortage allocation policies and detailed drought plan	10826(a)(8) 10826.2
II.7.7.3	3.4	Water uses within the service area, including all of the following:	10826(b)(5)
II.7.7.3	3.4 A	Agricultural.	10826(b)(5)(A)
II.7.7.3	3.4 B	Environmental.	10826(b)(5)(B)

AWMP Section	AWMP Guidebook Location	Description	Water Code Section (or as identified)
II.7.7.3	3.4 C	Recreational.	10826(b)(5)(C)
II.7.7.3	3.4 D	Municipal and industrial.	10826(b)(5)(D)
II.7.7.3	3.4 E	Groundwater recharge, including estimated flows from deep percolation from irrigation and seepage	10826(b)(5)(E)
II.7.6	3.5 A	Description of the quantity of agricultural water supplier's supplies as:	10826(b)
II.7.6.2	3.5 A.1	Surface water supply.	10826(b)(1)
II.7.6.3	3.5 A.2	Groundwater supply.	10826(b)(2)
II.7.6.4	3.5 A.3	Other water supplies, including recycled water	10826(b)(3)
II.7.7.4	3.5 A.4	Drainage from the water supplier's service area.	10826(b)(6)
II.7.6.5	3.5 B	Description of the quality of agricultural waters suppliers supplies as:	10826(b)
II.7.6.5	3.5 B.1	Surface water supply.	10826(b)(1)
II.7.6.5	3.5 B.2	Groundwater supply.	10826(b)(2)
II.7.6.5	3.5 B.3	Other water supplies.	10826(b)(3)
II.7.6.5	3.5 C	Source water quality monitoring practices.	10826(b)(4)
II.7.7, II.7.7.5	3.6	**Added to Water Code:** Annual water budget based on the quantification of all inflow and outflow components for the service area.	**Added to Water Code** 10826(c)
II.7.7.6, I.4.4	3.7 C	**Added to Water Code:** Identify water management objectives based on water budget to improve water system efficiency	**Added to Water Code** 10826(f)
II.7.7.7	3.8 D	**Added to Water Code** Quantify the efficiency of agricultural water use	**Added to Water Code** 10826(h)
II.7.8	3.9	Analysis of climate change effect on future water supplies analysis	10826(d)

AWMP Section	AWMP Guidebook Location	Description	Water Code Section (or as identified)
II.7.9	4	Water use efficiency	10826(e)
II.7.9		information required pursuant to § 10608.48.	
II.7.9	4.1	Implement efficient water management practices (EWMPs)	10608.48(a)
II.7.9.1	4.1 A	Implement Critical EWMP: Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of §531.10 and to implement paragraph (2).	10608.48(b)
II.7.9.1	4.1 A	Implement Critical EWMP: Adopt a pricing structure for water customers based at least in part on quantity delivered.	10608.48(b)
II.7.9.1	4.1 B	Implement additional locally cost-effective and technically feasible EWMPs	10608.48(c)
II.7.9.1	4.1 C	If applicable, document (in the report) the determination that EWMPs are not locally cost- effective or technically feasible	10608.48(d)
II.7.9.1	4.1 C	Include a report on which EWMPs have been implemented and planned to be implemented	10608.48(d)
II.7.9.2	4.1 C	Include (in the report) an estimate of the water use efficiency improvements that have occurred since the last report, and an estimate of the water use efficiency improvements estimated to occur five and 10 years in the future.	10608.48(d)
N/A	5	USBR water management/conservation plan may meet requirements for EWMPs	10608.48(f)
N/A	6 A	Lack of legal access certification (if water measuring not at farm gate or delivery point)	CCR§597.3(b)(2)(A)

AWMP Section	AWMP Guidebook Location	Description	Water Code Section (or as identified)
N/A	6 B	Lack of technical feasibility (if water measuring not at farm gate or delivery point)	CCR§597.3(b)(1)(B), §597.3(b)(2)(B)
N/A	6 A, 6 B	Delivery apportioning methodology (if water measuring not at farm gate or delivery point)	CCR§597.3.b(2)(C),
II.7.10.3	6 C	Description of water measurement BPP	CCR §597.4(e)(2)
II.7.10.3	6 D	Conversion to measurement to volume	CCR §597.4(e)(3)
II.7.10.3	6 E	Existing water measurement device corrective action plan? (if applicable, including schedule, budget and finance plan)	CCR §597.4(e)(4))

7.4 Plan Preparation and Adoption

7.4.1 Regulatory Compliance

As described previously, this AWMP has been prepared in accordance with AB 1668, the Water Conservation Act of 2009 (SBx7-7), and Agricultural Water Measurement requirements established in Title 23 of the California Code of Regulations (CCR), §597 et seq. WCWD supplies agricultural water to more than 25,000 irrigated acres, and is therefore required by California law to adopt and implement an AWMP and submit the AWMP to DWR.

7.4.2 Public Participation and Adoption

Requirements of the CWC and Government Code 6066 related to public review and adoption of AWMPs include the following:

- CWC §10821(a) – An agricultural water supplier required to prepare an AWMP must notify each city or county within which it supplies water that the AWMP will be prepared.
- CWC §10841 – Prior to adopting an AWMP, agricultural water suppliers must make the plan available for public inspection and hold a public hearing. Prior to the hearing, notice of the time and place must be published within the supplier's jurisdiction pursuant to Section 6066 of the Government Code.
- Government Code §6066 – Publication of notice shall be once a week for two successive weeks in a newspaper of general circulation.
- CWC §10843 – A copy of the adopted AWMP must be provided to the following entities within 30 days of the date of adoption:
    - The California Department of Water Resources (DWR),
    - Any city or county within which the supplier provides water,
    - Any groundwater management entity within which the supplier extracts or supplies water,
    - Any urban water supplier within which the supplier provides water,
    - Any city or county library within which the supplier provides water,
    - The California State Library, and
    - Any local agency formation commission serving a county within which the supplier provides water.
- CWC §10844 – Within 30 days of the date of adoption, the supplier must make the AWMP available on its website (if applicable), or submit an electronic copy to be made available by DWR.

The public participation and adoption process for WCWD is documented in Section 7.10.1.

7.4.3 Regional Coordination

This AWMP was originally developed as part of the Feather River Regional AWMP (FRRAWMP), which was funded by a Proposition 204 grant awarded by DWR to the Northern California Water

Association (NCWA). Development of the plan included coordination among the following Feather River water suppliers and water management entities:

- Joint Water Districts
    - Biggs – West Gridley Water District (BWGWD)
    - Butte Water District (BWD)
    - Richvale Irrigation District (RID)
    - Sutter Extension Water District (SEWD)
- Western Canal Water District (WCWD)
- Lower Feather Water Users
    - Feather Water District (FWD)
    - Garden Highway Mutual Water Company (GHMWC)
    - Plumas Mutual Water Company (PMWC)
    - Tudor Mutual Water Company (TMWC)
    - Sutter Butte – Butte Slough Water Users Association

Additionally, development of the FRRAWMP included consultation with representatives of the Butte County Department of Water and Resource Conservation, the California Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, and the DWR Northern Region.

The preparation of a regional AWMP for the Feather River region provides the opportunity to evaluate water management within the region as a whole and exposes interdependencies between agricultural water suppliers and other water uses, including other agriculture in the region and terrestrial and aquatic ecosystems. Water use in the region can be described as "cascading" where water diverted and applied on an individual farm or within an individual supplier service area that is not consumed to produce crops or habitat vegetation moves down through the system and remains available for other beneficial uses.

This 2020 update to WCWD's AWMP has been prepared by WCWD and builds upon and updates the 2015 AWMP, originally part of the 2014 FRRAWMP.

7.5 Background and Description of Service Area

7.5.1 History and Organization

Western Canal Water District (WCWD) was formed by a vote of landowners on December 18, 1984 and is a California Water District responsible for providing irrigation water to agricultural and environmental water users within its service area. Rice has been the primary crop grown within the service area since the canal was constructed and irrigation was made possible due to the predominance of heavy clay soils, favorable climate, and availability of water for irrigation.

The district was previously owned by the Pacific Gas and Electric Company (PG&E), who acquired it from the Great Western Power Company in 1930. The canal and diversion from the Feather River was originally designed and constructed by the Feather River Canal Company which was formed in 1908 and began surveying and construction work that same year. Due to a host of obstacles including difficulties obtaining rights of way and a financial depression, the Feather River Canal Company was unable to complete the project, although the canal was used in a limited capacity as early as 1911 (WCWD 2005b). In 1915, the Great Western Power Company purchased the canal, formed the Western Canal Company, completed construction of the canal, and expanded use of the canal for irrigation (McGee 1980). The canal and distribution system have expanded over the years, and the service area is currently comprised of approximately 66,200 gross acres, of which approximately 54,900 acres have been in agricultural production (i.e., irrigable) in recent years. WCWD's service area additionally includes approximately 7,100 acres of wetland and riparian vegetation, including portions of the CDFW Upper Butte Basin Wildlife Area and the USFWS North Central Valley Wildlife Management Area.

WCWD holds a pre-1914 water right for the diversion of up to 150,000 af of natural flow from the Feather River, subject to reduction during drought under terms of its 1986 diversion agreement with the State and a pre-1914 water right for diversion of up to 145,000 af of upstream stored water on the North Fork of the Feather River, not subject to reduction. The district also has adjudicated water rights on Butte Creek subject to surplus availability and dependent on hydrologic conditions. The maximum diversion is 9,300 af; average annual diversions have been approximately 7,000 af in recent years.

The district is represented by a five-member board of directors. Each director is elected for a four-year term by landowners within the district. The board of directors elect a board president to run the meetings, a vice-president to serve if the board president is unavailable, and a board treasurer. The general manager is the principal administrative officer of the district and serves as secretary to the board.

Currently, there are twelve full-time district employees. They include the general manager, operations manager, special projects manager, office manager, office assistant, and seven system operators. In addition to primary irrigation duties during the irrigation season, the staff additionally run fall and winter water deliveries for rice straw decomposition and habitat for waterfowl, shorebirds, and other species and perform winter maintenance activities. An organizational chart of the district is provided in Figure 7.1.

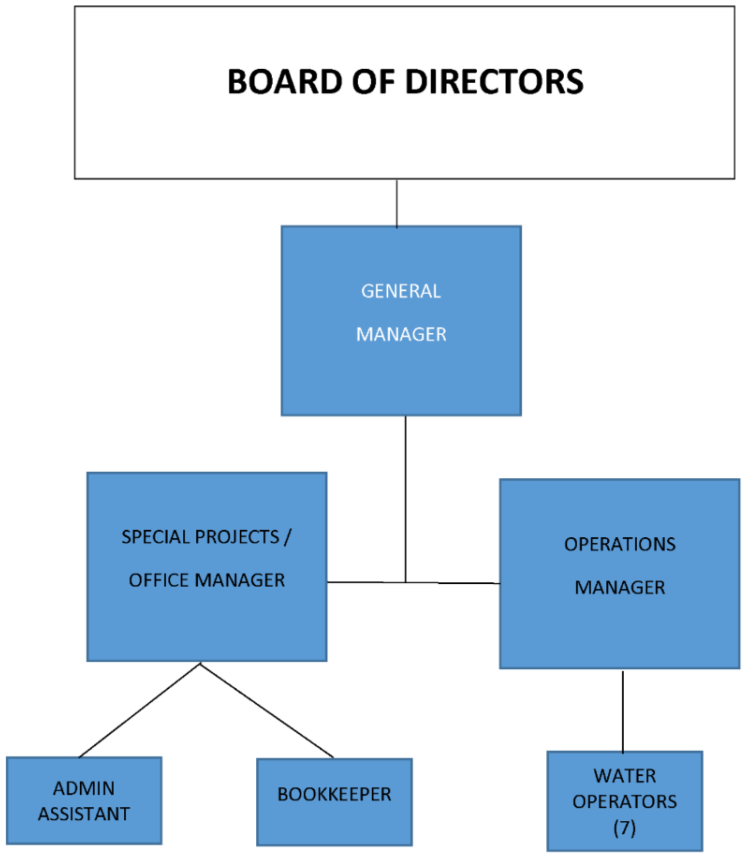

Figure 7.1. Organizational Chart.

7.5.2 Size and Location of Service Area

WCWD is located in the Sacramento Valley, east of the Sacramento River, west of the Feather River, and south of the city of Durham. District lands lie directly west and northwest of Thermalito Afterbay, and are bounded on the south by Richvale Irrigation District. Butte Creek, Little Dry Creek, Cherokee Canal, and Little Butte Creek all flow from north to south through the district, as well as several naturally occurring sloughs. The town of Nelson is located within the district's service area. Rice is the primary crop grown, constituting approximately 92% of the irrigated agricultural acreage in a given year. Wetland and riparian areas, including managed wildlife habitat, represent approximately 10% of the service area. The remaining lands are divided between orchards, row crops, and pasture.

WCWD's gross service area is approximately 66,200 acres, of which 54,900 acres have been in production in recent years.

The location of WCWD's service area relative to the Sacramento Valley as a whole and the Feather River Region is shown in Volume 1, Section 2 of this AWMP.

7.5.3 Distribution and Drainage System

The WCWD distribution system is shown in Figure 7.2. The figure shows the service area and surrounding areas, irrigation and drainage facilities, other waterways (including natural waterways), and points of inflow to and outflow from the district.

The distribution system is primarily an open, gravity flow system operated via upstream level control. Water is conveyed through a series of water level control structures used to maintain desired upstream water levels, subject to certain physical and operational constraints. There are some points of delivery for which low-lift pump stations are utilized to deliver water. These are typically in the northern portion of the district and are operated and maintained at grower expense. Daily diversions are adjusted through coordination with DWR operators to arrange releases from Thermalito Afterbay. Water level fluctuations in the afterbay result in fluctuations in delivery to WCWD which are propagated through the distribution system. At the ends of the laterals are safety spills used to convey operational spillage to drains and sloughs or to deliver water to downstream water users in some cases.

Water is diverted into the district via Thermalito Afterbay and Butte Creek. Water is diverted from the afterbay into two canals: the 22-mile Western Main Canal (capacity of 1,200 cfs) and the 0.5-mile 374 Lateral (capacity of 50 cfs). For the period 1999 to 2019, WCWD diverted between approximately 247,000 af and 333,000 af per year via the Western Main Canal, and between approximately 2,700 and 4,500 af per year via the 374 Lateral (also known as the PG&E Lateral)[2]. WCWD diverted an average of 5,900 af per year from Butte Creek at the Gorrill Ranch Diversion between 1999 and 2019. Total annual diversions for the District between 1999 and 2019 ranged from approximately 250,000 af to 341,000 af, with an overall average of 307,000 af per year. Annual diversions depend upon a combination of factors, including demands from the district's customers, deliveries to out of district landowners, availability of water in Butte Creek, and infrequent reductions based on the WCWD's settlement agreement with the State[3].

Annual diversions include diversions accounted against WCWD's allotment during the irrigation season, and diversions outside the irrigation season (not accounted against WCWD's allotment). Additionally, as a condition of its agreement with the State for diversion of water from the Feather River, WCWD can provide water to or receive water from the Joint Districts (RID, BWGWD, BWD, and SEWD).

The Western Main Canal is the backbone of the distribution system, carrying a majority of diversions. Deliveries to individual ranches and fields are made directly from the Main Canal, from 12 laterals totaling approximately 48 miles in length (which are either district-owned or on district rights-of-way), directly from Butte Creek at the Gorrill Ranch diversion, and via approximately 20

[2] Expressed on a water year basis (October – September) based upon data from USGS gages 11406880 and 11406900. Total annual diversions may exceed the District's 295,000 af entitlement in part due to non-allotted winter diversions for wildlife habitat and rice straw decomposition.
[3] Prior to 2015, the district's supply was reduced in only two years: 1991, and 1992. An additional reduction occurred in 1977, prior to the formation of WCWD. The district's supply was also reduced in 2015.

private laterals totaling 40 miles in length. Both district and private laterals typically originate from the Main Canal. The Main Canal includes approximately 13 primary control structures, five of which are automated to provide upstream water level control (four Langemann gates and one radial gate)[4]. There also exist additional, smaller control structures at lateral headings and along laterals control upstream water levels. Deliveries are made to fields and private laterals at approximately 250 locations, all of which are measured and billed on a volumetric basis.

In addition to the primary WCWD distribution system, portions of Little Dry Creek, which the Main Canal bypasses via an inverted siphon, are used to convey water. Specifically, water can be sent to Little Dry Creek on the upstream side of the siphon, through which it flows into Richvale Irrigation District and is diverted approximately 7 miles downstream of the Main Canal to irrigate a small portion of WCWD on the east side of Butte Creek.

The District is divided into seven operational divisions. The divisions operate under the supervision of the operations manager and the general manager. Within divisions, actual field operations are executed by the seven system operators. Division sizes average approximately 8,300 acres. The divisions have been delineated to achieve uniform division of workload among operators.

The distribution and drainage system and natural waterways within WCWD are integrated. For example, the Western Main Canal comingles with Little Butte Creek in an area known as "the Reservoir". Two temporary weir structures are installed in the creek to raise the water level and provide sufficient head for flow in the canal as it travels across the creek to the west. Also, in the southwestern portion of WCWD water is conveyed through sloughs and pumped out by downstream water users in several instances. The entire irrigation and drainage system consists of unlined ditches. Seepage losses are limited by clay soils with underlying hardpan layers and shallow groundwater conditions.

Drainage occurs through both naturally occurring waterways and manmade drains. Overall, there are approximately 40 miles of primary drains and 500 miles of secondary drains in the district (WCWD 2005b), none of which are actively operated or maintained by WCWD. Drainage District 200 (DD200) operates and maintains the drains east of Cherokee Canal, and Drainage District 100 (DD100) operates and maintains the drains east of Little Dry Creek and west of Cherokee Canal in the southern portion of the district. Many manmade drains flow to natural waterways, including Cherokee Canal (modified portion of Dry Creek), Little Dry Creek, and Butte Creek. Lands within WCWD ultimately either drain to Butte Creek or into Richvale Irrigation District via Little Dry Creek, Cherokee Canal, or the DD100 and DD200 drains.

[4] One additional structure, the Nelson Check, will be replaced and automated during the 2015-20156winter period.

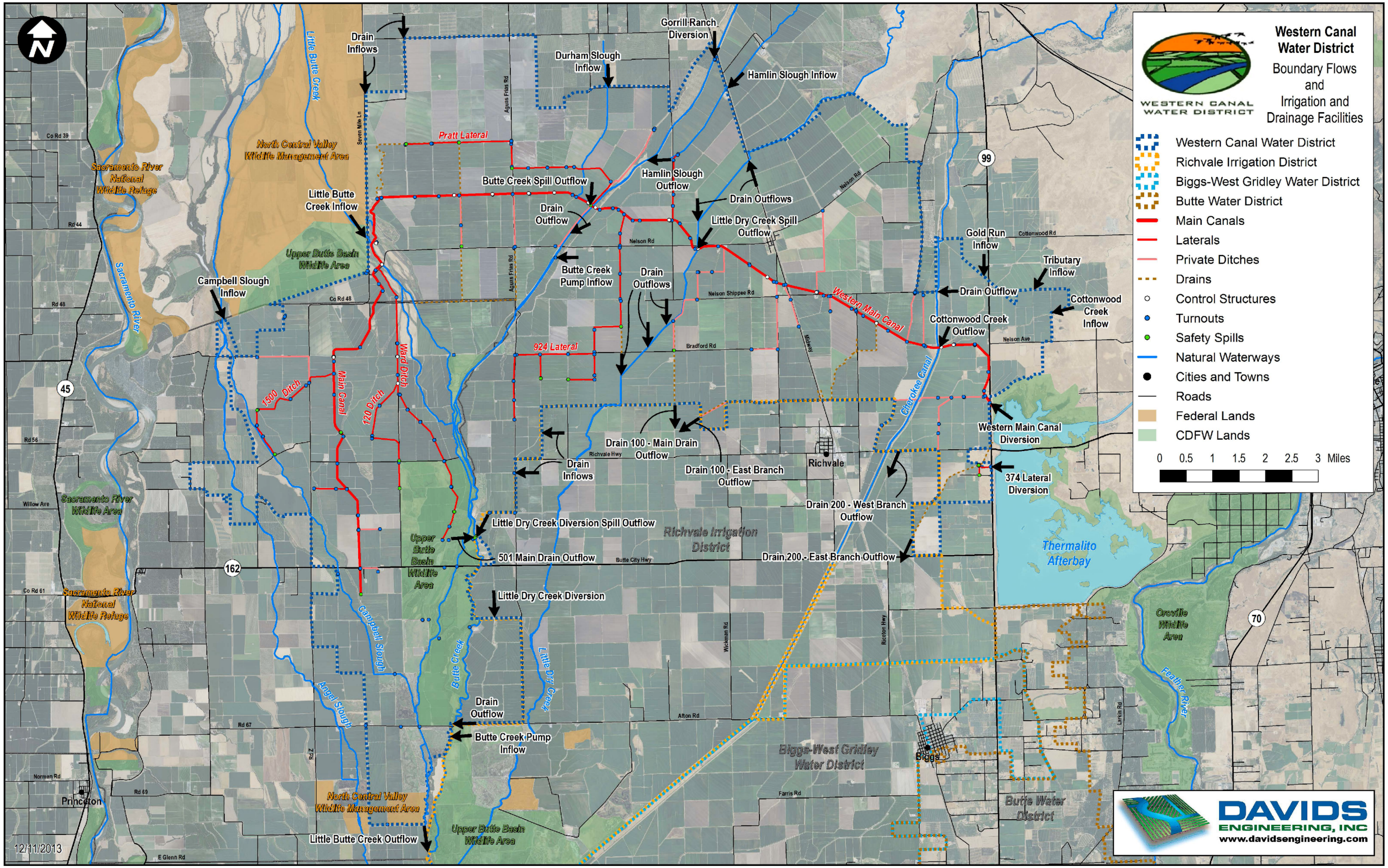

Figure 7.2. Boundary Flows and Irrigation and Drainage Facilities.

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At two locations tailwater and spillage from the distribution system is recovered by the district from drains for reuse. In 2004, the district completed a study to determine the feasibility of tailwater recovery in other locations (MBK 2004). The study determined that additional tailwater recovery was not economically feasible based on the estimated costs of tailwater recovery via pumping and pipelines and due to additional water available for use via gravity from Thermalito Afterbay.

WCWD is dominated by rice, and its delivery practices have been established to best suit customer needs. During periods of flood-up in the spring, water has historically been delivered on an arranged-demand basis, where growers place orders directly with system operators, and water deliveries are generally made in the sequence orders were received, subject to operational constraints. Once rice is established, continuous deliveries are made as needed to maintain rice pond levels (except when deliveries are ceased and water is held or drained to support chemical applications), with potential periodic adjustments to match crop evapotranspiration and deep percolation rates while limiting tailwater outflow. For additional detail describing water management objectives for rice production, see Volume I, Section 4 of this AWMP. Orders for initial flood-up at the beginning of the irrigation season are generally filled within 48 hours. During the irrigation season, orders are generally filled with 24-hours lead time and are often filled with less lead time when operational constraints allow.

The irrigation season begins in April or May with flood up of the rice fields. Following flood up, diversions and deliveries remain relatively steady to maintain pond levels, with individual fields being drained for herbicide applications and re-flooded in some cases. Deliveries typically decrease in August and September in preparation for harvest. Fall and winter deliveries for rice straw decomposition begin in October and continue through mid-January. Winter flooding is integral to rice production in the Sacramento Valley and provides waterfowl and shorebird habitat. From the period of 1999 through 2019, diversions during the irrigation season (April through September) have been relatively consistent. Irrigation season diversions ranged between 181,000 and 259,000 af from 1999 to 2019, with an average of 226,000 af. Fall and winter diversions increased between 1992 and 2001 and have since remained relatively steady. The increase is primarily a result of the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991, which phased out rice straw burning, except under special circumstances during this period. Instead of burning, rice straw is now typically decomposed via winter flooding between November and January, with the flooded fields providing important food and habitat for migratory waterfowl, shorebirds, and other species.

7.5.4 Terrain and Soils

WCWD is located on the Sacramento Valley floor, and the topography within the district is generally flat. Land surface elevation varies from approximately 150 feet above mean sea level in the northeastern portion of the district to about 65 feet in the southwest. The land falls to the southwest at approximately 0.8 feet per thousand feet (0.08 percent) with lesser slopes in the southwest as compared to the northeast. As mentioned previously, drainage within the district generally flows south and west towards Butte Creek and Little Dry Creek with some drainage south to RID through the DD100 and DD200 drains.

Soils within the district can be generally classified as clayey alluvium over cemented loamy alluvium. Eight soil map units, as defined by the Natural Resources Conservation Service (NRCS 2006a, 2006b, 2009a), comprise approximately 91 percent of the irrigated area. Characteristics of these map units are summarized in Table 7.2. For over 90 percent of the area, available water holding capacity exceeds five inches in the top five feet. The soils are poorly drained with typically very low saturated hydraulic conductivity. A restrictive, duripan layer exists generally throughout the district, typically at a depth of 20 to 60 inches. The depth to shallow groundwater is typically less than five feet. The soils are well suited for rice production.

Table 7.2. Characteristics of Dominant Soils (NRCS 2006).

Soil Map Unit	Percent of Area	Landform(s)	Slope Range	Parent Material	Available Water Holding Capacity	Drainage	Saturated Hydraulic Conductivity Class	Restrictive Layer	Depth to Water Table	Typical Profile[1]	
Esquon-Neerdobe Complex	42%	basin floors on valleys	0 to 1 percent	clayey alluvium over cemented loamy alluvium	5.8 to 8.9 inches in top five feet	poorly drained	very low	duripan at 20 to 60 inches	20 to 59 inches	0 - 46 inches: 46 - 56 inches: 56 - 67 inches:	clay silty clay cemented material
Lofgren-Blavo Complex	20%	basin floors on valleys	0 to 1 percent	clayey alluvium over cemented loamy alluvium	5.3 to 6.7 inches in top 5 feet	poorly drained	very low	duripan at 20 to 60 inches	20 to 59 inches	0 - 44 inches: 44 - 47 inches: 47 - 62 inches:	clay clay loam cemented material
Landlow Clay	13%	basin floors on valleys	0 to 1 percent	alluvium derived from igneous rock	5.3 inches in top 5 feet	somewhat poorly drained	very low	duripan at 30 to 45 inches	0 to 30 inches	0 - 35 inches: 35 - 60 inches:	clay cemented material
Stockton Clay	8%	basin floors on valleys	0 to 1 percent	alluvium derived from andesite	4.5 to 9.0 inches in top 5 feet	somewhat poorly drained	very low	duripan at 20 to 60 inches	36 to 48 inches	0 to 54 inches: 54 to 60 inches:	clay cemented material
Duric Xerarents-Eastbiggs Complex	3%	terraces on valleys	0 to 1 percent	clayey alluvium over cemented loamy alluvium	2.3 to 7.1 inches in top 5 feet	somewhat poorly drained	very low	duripan at 6 to 80 inches	4 inches to more than 60 inches	0 - 10 inches: 10 - 13 inches: 13 - 60 inches:	clay loam clay cemented material
Marvin Silty Clay Loam	3%	flood plains	0 to 2 percent	alluvium	6.6 to 9.1 inches in top 5 feet	somewhat poorly drained	moderately low	none	39 inches	0 to 13 inches: 13 to 60 inches:	silty clay loam clay
Marvin Silty Clay	2%	flood plains	0 to 1 percent	alluvium			moderately low	none	39 inches	0 to 13 inches:	silty clay

Soil Map Unit	Percent of Area	Landform(s)	Slope Range	Parent Material	Available Water Holding Capacity	Drainage	Saturated Hydraulic Conductivity Class	Restrictive Layer	Depth to Water Table	Typical Profile[1]	
					9.0 inches in top 5 feet	somewhat poorly drained				13 to 60 inches:	clay
Edjobe Silty Clay	1%	basin floors on valleys	0 to 1 percent	clayey alluvium over cemented loamy alluvium	12.1 inches in top 5 feet	poorly drained	low	duripan at 60 to 80 inches	30 to 69 inches	0 to 32 inches:	silty clay
										32 to 48 inches:	silty clay loam
										48 to 69 inches:	clay loam
										69 to 75 inches:	cemented material

1. For complexes, which contain a combination of distinct map units, the typical profile describes the primary map unit.

7.5.5 Climate

The climate statistics presented in this section are based on the Durham CIMIS station (#12) for the period October 1984 to September 2020. The station is located approximately one mile north of the district's service area and considered representative of WCWD and the Feather River region as a whole.

WCWD has a climate typical of the eastern Sacramento Valley, with mild winters with mild to moderate precipitation and warm to hot, dry summers. Average daily maximum temperatures range from a low of about 55°F in December to a high of approximately 91°F in July (Table 7.3). Mean daily minimum temperatures range from a low of approximately 37°F in December and January to a high of about 60°F in July.

Average annual reference evapotranspiration (ET_o) is approximately 51 inches, ranging from a low of one inch in December and January to a high of over seven inches in June and July. Approximately 75 percent of annual ET_o occurs in the six-month period from April through September.

Average annual precipitation is approximately 23 inches, with 17 inches or slightly more than 75 percent occurring in the five month period from November through March.

Even during the peak summer period, the average maximum relative humidity reaches between 80 and 90 percent, which is indicative of an irrigated area, and remains near or above 90 percent throughout the year. Minimum relative humidity ranges between approximately 35 to 40 percent during the summer and roughly 45 to 65 percent during the wet winter months.

Average wind speed is lowest during the summer in August (3.3 miles per hour) and greatest during late winter and early spring during February and March (5.0 five miles per hour).

There are no significant microclimates within the district that affect water management or operations.

Table 7.3. Mean Daily Weather Parameters by Month at Durham CIMIS Station (October 1984 to September 2020).

Month	Total ET_o (in)	Total Precip. (in)	Average Daily Temperature (F)			Average Relative Humidity (%)			Average Wind Speed (mi/hr)
			Avg.	Min.	Max.	Avg.	Min.	Max.	
January	1.2	4.0	45.6	37.2	55.6	80	62	93	4.4
February	2.0	3.7	49.8	39.4	61.4	70	49	89	5.0
March	3.4	3.1	54.1	42.3	66.5	67	44	89	5.0
April	4.8	1.5	59.1	45.6	72.9	61	37	88	4.8
May	6.5	1.2	66.5	52.1	80.5	58	36	87	4.6
June	7.4	0.6	72.5	57.8	86.9	57	34	86	4.3
July	7.7	0.1	75.8	60.3	91.3	60	37	89	3.5
August	6.7	0.1	73.8	58.3	90.3	61	37	90	3.3
September	5.0	0.4	69.8	54.7	87.1	58	33	87	3.5
October	3.4	1.4	61.6	48.0	78.0	60	35	87	3.7
November	1.7	2.7	51.3	40.5	64.3	73	50	92	3.9
December	1.1	3.9	45.0	36.5	54.9	79	61	93	4.5
Annual	**50.8**	**22.7**	**60.4**	**47.7**	**74.1**	**65**	**43**	**89**	**4.2**

7.5.6 Operating Rules and Regulations

The district's bylaws are occasionally reviewed and revised as needed to address changing conditions. The bylaws prescribe conditions that ensure distribution of irrigation water to users in an orderly, efficient and equitable manner; they are available to water users and are included at the end of this chapter for convenient reference (Section 7.10.2).

7.5.7 Water Delivery Measurement and Calculation

The delivery measurement requirements of the Water Conservation Act of 2009 (SBx7-7) and California Code of Regulations Title 23 §597 (CCR 23 §597) state that agricultural water suppliers subject to the law shall measure the volume of water delivered to customers with sufficient accuracy to (1) enable reporting of aggregated farm-gate delivery data to the State and (2) adopt a pricing structure for water customers based at least in part on the quantity of water delivered. In addition, CCR 23 §597 specifies minimum accuracy requirements for delivery measurement devices and requires certification of volumetric delivery measurement accuracy by a California registered professional engineer. WCWD currently measures all water deliveries within the district and bills on a completely volumetric basis.

Deliveries are measured using open channel propeller meters and lift pump propeller meters. The meters provide measurements of both flow rate (cfs) and volume (af). Each meter is inspected and readings of instantaneous flow and accumulated volume are recorded on a daily basis. WCWD also owns and operates a meter testing and calibration facility, built in 2002 to replace a previously existing facility. The facility allows staff to ensure meters are calibrated and working correctly before deployment at delivery points. Additional detail describing WCWD's delivery measurement program and its compliance with CCR 23 §597 are provided in Section 7.10.3.

Billing for delivered water is on a volumetric basis during both the irrigation season and the winter period. In the mid-1980's, WCWD billed growers on a volumetric basis, with a minimum charge of 5 af/ac. Following that time, as operating revenues stabilized, the per-acre minimum was reduced to 1 af/ac, which encourages growers to conserve water and reduce on-farm water demands. WCWD's delivery measurement program and volumetric pricing structure satisfy the CCR 23 §597 based on field testing performed during 2014, as described in Section 7.10.3.

7.5.8 Water Rate Schedules and Billing

As described previously, WCWD has billed customers for water deliveries on a volumetric basis since its inception in 1984. A standby charge for water service is also paid by district customers. The standby charge in 2020 was $10 per acre. Rates are updated periodically by the board of directors in compliance with Proposition 218. The volumetric rate for the 2020 spring-summer irrigation season was $4 per af with a minimum charge of $4 per acre and $8 per-acre minimum for one-time flooding. Water is similarly provided during the winter period (October through January), when available, for rice straw decomposition and habitat at a cost of $4 per af with a minimum charge of $4 per acre.

Additionally, WCWD provides water under individual agreements with landowners outside of its service area. This water is available at the rate of $8 per af with a minimum charge of $8 per acre. Under these agreements, water delivery is dependent on WCWD's ability to adequately supply customers within the official, permanent service area. In the event of a water shortage, water deliveries outside the service area are subject to interruption or termination. Before an application for water delivery outside the service area is approved, the applicant must ensure that an alternate supply is available in the event of an interruption or termination.

Two applications for water service, one for the irrigation season and one for the winter period, are made annually by customers inside and outside the permanent service area. For each application, the landowner specifies the type of irrigation service, acreage, meter station number, crop to be grown (or other land use), and land description (maps are requested). Bills are sent out in early October for the irrigation season and in February for the winter period; they are due 60 days after the billing date. Unpaid bills remaining after this date are considered delinquent, and an interest charge of 1.5% per month is assessed on the unpaid balance still outstanding 30 days after the delinquent date.

7.5.9 Water Shortage Allocation Policies and Drought Management Plan

On April 1, 2015 Governor Brown issued Executive Order B-29-15, mandating agricultural water suppliers to include a detailed Drought Management Plan (DMP) describing actions and measures taken to manage water demand during drought in their 2015 Agricultural Water Management Plan (AWMP) update. Three years later Assembly Bill 1668 (AB 1668) was passed on May 31, 2018. AB 1668 amended the California Water Code and requirements for AWMPs, including detailing requirements for a Drought Plan, or DMP (CWC 10826.2). WCWD's 2020 DMP is attached in Section II.7.10.5.

WCWD has historically experienced very reliable surface water supplies with a full surface water supply of 295,000 acre-feet available in all but three years (1991, 1992, and 2015) since construction of Lake Oroville and its subsequent 1969 settlement agreement with the State. During years in which curtailment is allowed under the agreement, WCWD's water right for 150,000 of natural flow from the Feather River can be reduced by up to 50 percent, as discussed in greater detail in the attached DMP (Section II.7.10.5).

The DMP describes WCWD's broad range of drought resilience efforts, and specific drought response actions undertaken during drought to manage available water supplies and meet customer demands to the maximum extent possible. The 2020 DMP includes the components required by CWC 10826.2 and recommended by DWR in its 2020 AWMP Guidebook for inclusion (DWR 2020).

7.5.10 Policies Addressing Wasteful Use of Water

WCWD encourages efficient field-scale water use by billing for delivered water on a volumetric basis. The district also actively prohibits the wasteful use of water, as described in its bylaws (Section 7.10.2). Enforcement actions include withholding water for willful wasteful use. The district's policies regarding unauthorized uses of water and enforcement are described in detail in the bylaws. Water use that could be considered waste within the district remains available to provide groundwater recharge or is available downstream for agricultural or environmental water uses; regardless, the district actively prohibits excessive water use.

7.6 Inventory of Water Supplies

7.6.1 Introduction

This section provides a brief description of surface water and groundwater supplies within WCWD as well as a description of WCWD water quality monitoring practices.

7.6.2 Surface Water Supply

As described in Section 7.5.1, WCWD holds a pre-1914 water right for the diversion of up to 150,000 af of natural flow from the Feather River, subject to reduction during drought under terms of its 1986 diversion agreement with the State and a pre-1914 water right for diversion of up to 145,000 af of upstream stored water on the North Fork of the Feather River, not subject to reduction. The district also has an adjudicated water right on Butte Creek subject to surplus availability and dependent on hydrologic conditions. The maximum diversion is 9,300 af; average annual diversions have been approximately 7,800 af in recent years. Surface water within WCWD is available for reuse by the district and individual water users.

7.6.3 Groundwater Supply

WCWD overlies the Butte subbasin of the Sacramento Valley groundwater basin. The water-bearing formations of the subbasins consist of a combination of Holocene, Pleistocene, and Pliocene deposits and alluvium. The formations, size, and other features of the subbasins are described in Volume I, Section 2.7.2 of this AWMP.

The California Statewide Groundwater Elevation Monitoring (CASGEM) program's groundwater basin prioritization process has resulted in the designation of the Butte subbasin as a medium priority basin with respect to the need to help identify, evaluate, and determine the need for additional groundwater level monitoring (DWR 2020). The basin prioritization process considers eight data components: population, population growth, number of public supply wells, irrigated acreage, groundwater reliance, documented impacts (overdraft, subsidence, saline intrusion, and other groundwater quality issues), and other information determined to be relevant.

WCWD has a history of actively participating in groundwater management initiatives in the Butte subbasin and Butte County as a whole. Most recently, WCWD has embarked on the implementation of the Sustainable Groundwater Management Act of 2014 (SGMA) as a local Groundwater Sustainability Agency (GSA) in the subbasin. SGMA represents a major shift in the management of California's groundwater resources, allowing local agencies to prepare and adopt Groundwater Sustainability Plans (GSPs) tailored to achieving sustainability of underlying groundwater basins and subbasins through local actions. For the Butte subbasin, under the Law, a GSP or combination of GSPs addressing the entirety of each subbasin must be prepared and adopted by January 31, 2022. The following agencies have formed GSAs in the Butte subbasin:

- Colusa Groundwater Authority
- Reclamation District No. 2106

- Reclamation District No. 1004
- City of Gridley
- City of Biggs
- County of Butte
- Western Canal Water District
- Butte Water District
- Biggs-West Gridley Water District
- Richvale Irrigation District
- County of Glenn

Moving forward, WCWD will actively collaborate with other GSAs and interested parties in the subbasins to sustainably manage available groundwater resources. The development and use of surface water supplies by WCWD and others over the past century has greatly contributed to the sustainability of the groundwater system through beneficial recharge and prevention of pumping that would otherwise have occurred.

Prior to SGMA, WCWD adopted an AB 3030 compliant groundwater management plan (GMP) in 1995 with the purpose of formalizing a management plan to monitor, analyze, and implement effective water management practices to utilize and protect the district's valuable groundwater resources (WCWD 1995). The GMP was updated in 2005 to comply with the requirements of SB 1938 (WCWD 2005a). As part of GMP implementation, WCWD coordinates and cooperates with other local water management entities to preserve, protect, and monitor groundwater extraction, distribution, and allocation within the subbasin. Components of WCWD's GMP include the following:

- Control of saline water intrusion,
- Regulation of migration of contaminated groundwater,
- Mitigation of overdraft conditions,
- Replenishment of groundwater extracted by water producers,
- Monitoring of groundwater extracted by water producers, and
- Facilitation of conjunctive use operations.

Additionally, as a member of the Butte Basin Water Users Association, WCWD was a participant in the development of the Butte County GMP finalized in 2004. The Butte County GMP accomplishes the following (CDM 2004):

- Supports the long-term maintenance of high-quality groundwater resources within the county for agricultural, environmental, rural domestic and urban needs;
- Documents the county's existing groundwater management programs;
- Describes potential actions to increase the effectiveness of groundwater management; and
- Meet requirements of available grant funding opportunities.

Objectives of the Butte County GMP include the following:

- Minimize the long-term drawdown of groundwater levels,
- Protect groundwater quality,
- Prevent inelastic land surface subsidence resulting from groundwater pumping,
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality,
- Minimize the effect of groundwater pumping on surface water flows and quality,
- Evaluate groundwater replenishment and cooperative management projects, and
- Provide effective and efficient management of groundwater recharge projects and areas.

In addition to developing the Butte County GMP, the county board of supervisors approved a groundwater management ordinance in 2004 to support the development of quantitative Basin Management Objectives (BMOs). Specific BMOs address the following:

- Groundwater levels,
- Groundwater quality, and
- Inelastic land subsidence,

WCWD does not own any groundwater wells. Average private pumping within WCWD for irrigation and wildlife habitat is estimated to be approximately 6,000 af annually in recent years. Additional pumping occurred in 2015 in response to curtailment of Feather River surface water supplies; an estimated 36,000 af of groundwater was pumped between April and October of 2015.

7.6.4 Other Water Supplies

WCWD does not have access to water supplies other than those described previously in section 7.6.

7.6.5 Water Quality Monitoring Practices

Water quality monitoring has been performed in the past and continues to be performed by other water and resource management entities including DWR, the U.S. Geological Survey, the county, other water suppliers, and through water quality coalitions, as described in the following paragraphs. Surface water and groundwater within WCWD are of excellent quality for irrigation and wildlife habitat.

The Western Canal Groundwater Test Program conducted by DWR (1991) evaluated water quality in several wells within WCWD. Parameters evaluated included temperature, pH, electrical conductivity, minerals, and nutrients. Butte County monitors groundwater quality at a network of 13 wells distributed among county subinventory units. Two of these wells are located within WCWD. Monitoring is conducted as part of implementation of the Butte County GMP adopted in 2004, though monitoring began in 2002. Water quality parameters monitored include temperature, pH, and electrical conductivity. Additional detail describing groundwater quality in WCWD is provided in the district's 2005 AWMP.

Growers within WCWD participate in the Sacramento Valley Water Quality Coalition and/or the California Rice Commission Coalition, which conduct monitoring of surface water quality in compliance with the CVRWQCB's Irrigated Lands Regulatory Program (ILRP). The monitoring program includes sampling and testing of a host of parameters for hundreds of samples collected annually from sites strategically distributed throughout the Sacramento River basin, which includes the Feather River region.

WCWD is a party to a settlement agreement with DWR and three other districts (BWGWD, BWD, and RID) that addresses yield losses from lower water temperatures that result from the operation of Lake Oroville, as compared to pre-reservoir conditions. As part of the process to develop the settlement agreement, WCWD, DWR, and the other districts developed and implemented a method to estimate rice yield reductions through detailed monitoring of water temperatures and yields.

In 2014, NCWA prepared a groundwater quality assessment report for the Sacramento Valley to evaluate the sources of salt and nitrate loads and potential long-term effects on surface water and groundwater resources. This information supports understanding of sustainable management of surface water and groundwater supplies, including conjunctive management opportunities and limitations. The primary objectives of the assessment were to (1) identify known groundwater quality impacts exist, (2) prioritize high vulnerability areas, and (3) evaluate opportunities to incorporate existing groundwater monitoring efforts to achieve water management objectives.

7.7 Water Balance

7.7.1 Overview

This section describes the various uses of water within WCWD between 1999 and 2019, followed by detailed water balances for key accounting centers within the district. Water balances are presented for the distribution and drainage system (i.e. canals and drains), farmed lands, and the district as a whole. The water balances quantify all substantial inflows to and outflows from the WCWD service area on an irrigation season (April – September) and water year basis (October – September). The period from 1999 to 2019 has been chosen because it depicts recent water management conditions. Key drivers of water management variability across years include precipitation timing and amounts, crop idling for water transfers, and surface water reductions. Surface water reductions only occurred in one year, 2015, during the period from 1999 to 2019. Conditions in curtailed years are discussed in greater detail in the Drought Management Plan, included as Attachment 7.10.5 of this AWMP.

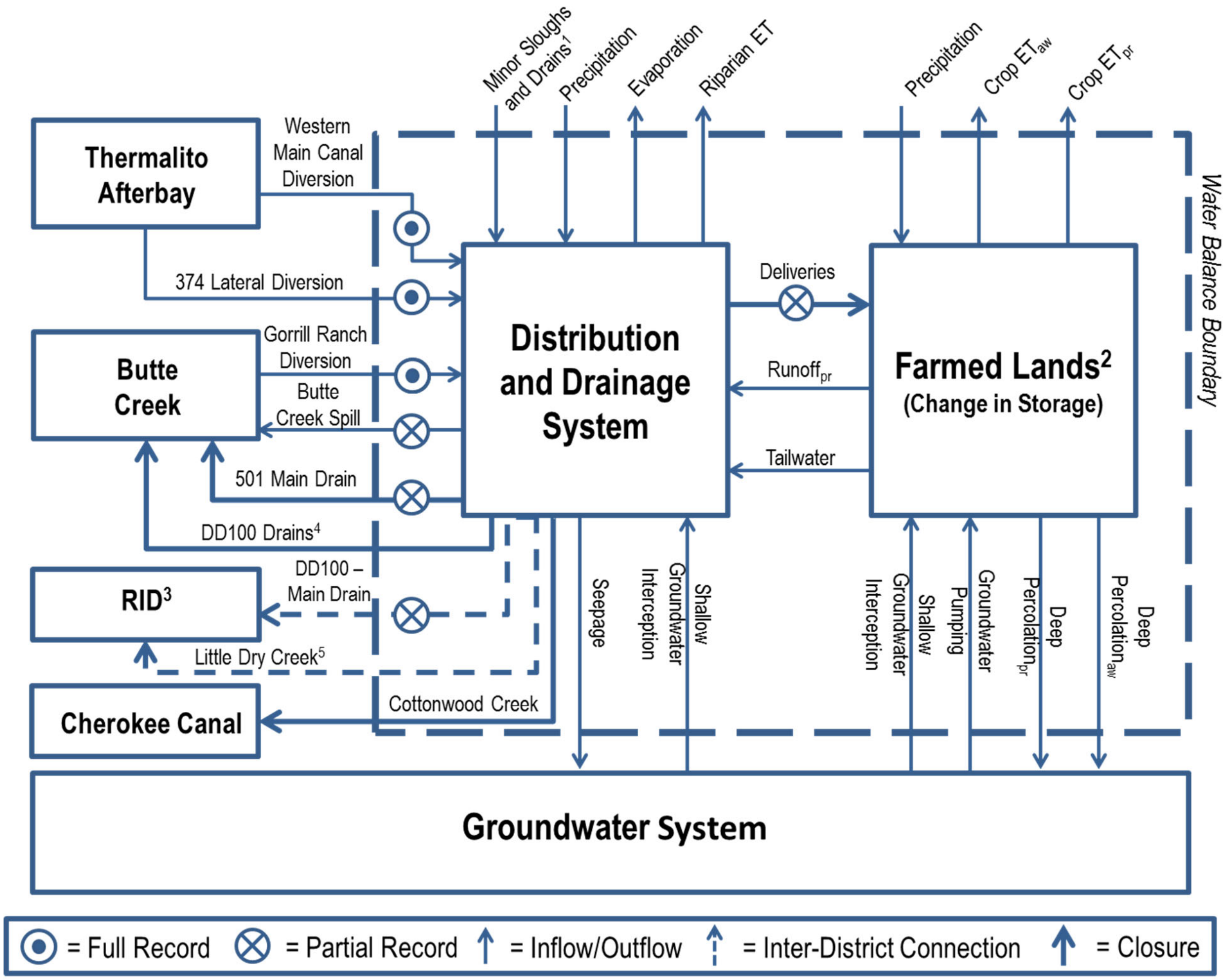
Historical estimates of water use may differ slightly from those presented in WCWD's 2015 AWMP as a result of refinements to the analyses used to develop the estimates, but fall within the range of uncertainty presented in Table 7.4 and do not affect conclusions regarding water management conditions within WCWD.

The remainder of this section includes the following subsections:

- Analytical Approach – Description of mass balance approach for water balance analysis, methodologies for estimation of individual flow paths, and uncertainty in flow path estimates;
- Water Uses – Description of water use for agricultural, environmental and recreational, municipal and industrial, groundwater recharge, and transfer and exchange purposes;
- Drainage – Description of drainage occurring within and flowing from the district; and
- Water Accounting (Water Balance Summary) – Summary of monthly and annual inflows to and outflows from the district, including a discussion of existing water management and performance.

7.7.2 Analytical Approach

The WCWD water balance includes separate accounting centers for the distribution and drainage system and the farmed lands within the service area. A total of 25 individual flow paths are estimated. A schematic of the water balance structure is provided in Figure 7.3. The schematic identifies sources and destinations of water, accounting centers, and individual flow paths by which water enters and leaves the system.



1. Minor sloughs and drains include Campbell Slough, Little Butte Creek, Durham Slough, Hamlin Slough, the Little Dry Creek Diversion, and other tributaries and drains.
2. Farmed Lands includes portions of Upper Butte Basin Wildlife Area and North Central Valley Wildlife Management Area.
3. RID is Richvale Irrigation District.
4. DD100 Drains to Butte Creek also includes Hamlin Slough, Little Butte Creek, Campbell Slough, and private drains.
5. Little Dry Creek to RID also includes DD100 and DD200 Drains and private drains

Figure 7.3. Water Balance Structure.

Mass Balance

In general, flow paths are quantified on a monthly basis. For each accounting center, water volumes associated with certain flow paths are estimated independently based on measured data or calculated estimates, and the remaining flow is then calculated based on the principal of conservation of mass (Equation 7.1), which states that the difference between total inflows to and total outflows from an accounting center for a given period of time is equivalent to the change in stored water within that accounting center. For the distribution and drainage system, the change in storage is assumed to be zero on a monthly basis. For the farmed lands, the monthly change in storage varies, reflecting changes in the volume of water ponded in rice and managed wetlands areas as well as changes in soil moisture stored in the root zone. Over the course of a year the change in storage across all farmed lands is expected to be near zero.

$$Inflows - Outflows = Change\ in\ Storage\ (monthly\ time\ step) \qquad [7.1]$$

The flow path that is calculated based on Equation 7.1 is referred to as the "closure term" because the mass balance equation is solved for or "closed" on the unknown quantity. The closure term is selected based on consideration of the availability of data or other information to support an independent estimate as well as the volume of water representing the flow path relative to the size of other flow paths. Generally speaking, the largest, most uncertain flow path is selected as the closure term.

Flow Path Estimation and Uncertainty

Individual flow paths were estimated based on direct measurements or based on calculations using measurements and other available data. As described previously, those flow paths not estimated independently were calculated as the closure term of each accounting center.

The analysis results for each flow path are reported with a high level of precision (nearest whole acre-foot) that implies a higher degree of accuracy than is actually justified. The estimated percent uncertainty (approximately equivalent to a 95 percent confidence interval) in each measured or calculated flow path has been estimated as part of the water balance analysis. Based on the relative magnitude of each flow path, the resulting uncertainty in each closure term can be estimated by assuming that errors in estimates are random (Clemmens and Burt 1997). Errors in estimates for individual flow paths may cancel each other out to some degree, but the combined error due to uncertainty in the various estimated flow paths is ultimately expressed in the closure term.

For the distribution and drainage system accounting center, aggregated surface outflows were calculated as the closure term, based on the assumption that the change in storage over time is zero. Total outflows were distributed across each individual outflow waterway (i.e. creeks and drains) based on available outflow measurements and estimated drainage areas tributary to each outflow location. Aggregated surface outflows were selected as the closure term because of the combination of the lack of available outflow data, generally large magnitude, and relative uncertainty of the flow path.

For the farmed lands accounting center, deliveries were calculated as the closure term. Deliveries were selected as the closure term because historical measurements were not readily available for the full period of analysis and they represent the largest inflow into the farmed lands accounting center. Deliveries calculated via closure include deliveries by WCWD from canals and laterals, as well as any district or private reuse of water or unaccounted groundwater pumping.

Table 7.4 lists each flow path included in the water balance indicating which accounting center(s) it belongs to; whether it is an inflow or an outflow; whether it was measured or calculated; the supporting information and assumptions used to determine it; the estimated uncertainty, expressed as a percent; and average values for the period of analysis. Results for both the full water year and for the primary irrigation season (April to September) are provided. As indicated, estimated uncertainties vary from 5% to 100% of the average volume for the irrigation season, with uncertainties generally being less for measured flow paths and greater for calculated flow paths.

The estimated uncertainty of each closure term is also shown. As indicated, the estimated uncertainty in aggregated surface outflows is 31% for the water year as a whole and 46% for the irrigation season. The estimated uncertainty in deliveries is 15% for the water year as a whole and 12% for the irrigation season. The uncertainty in deliveries decreases for the irrigation season due to the lack of precipitation from winter storms.

7.7.3 Water Use

The district supplies agricultural irrigation water and also provides water for environmental use to provide wildlife habitat within and outside its service area. These water uses are described in greater detail in the remainder of this section.

Agricultural

Agricultural irrigation is by far the dominant water use in WCWD. Between 1999 and 2019, there were an average of 49,600 cropped acres within the district's service area, with an average of 4,800 additional acres of fallow or idle land.

Table 7.5 and Figure 7.4 present estimated irrigable acreages for this period. As indicated, the main crop in the district is rice, which was grown on an average of 46,600 acres between 1999 and 2019, representing 94% of the total cropped area, or 86% of the irrigable area. Orchards account for an average of 1,800 acres or 4% of the cropped area. Other crops such as grain, hay, and pasture account for an average of 1,200 acres or 3% of the cropped area. The acreage of other crops has decreased over time.

Crop acreage decreased in 2001, 2003, 2008, 2009, 2010, 2012, 2014, and 2018 as a result of crop idling-based water transfers. Cropped acreage within these years averaged 46,900 acres, with an average of 51,400 acres in years in which cropland was not idled for transfer.

Table 7.4. Water Balance Flow Paths, Supporting Data, and Estimated Uncertainty.

Account-ing Center	Flow Path Type	Flow Path	Source	Supporting Data	Water Year (Oct. - Sept.)		Irrigation Season (Apr. - Sept.)	
					Average Volume (af)	Estimated Uncertainty	Average Volume (af)	Estimated Uncertainty
District Distribution and Drainage System	Inflow	Western Main Canal Diversion	Measurement	USGS Measurement Gage 11406880	297,146	5%	216,614	5%
		374 Lateral Diversion	Measurement	USGS Measurement Gage 11406900	3,787	5%	3,006	5%
		Gorrill Ranch Diversion	Calculation	WCWD operational data (1999-2012 Diversion Record)	5,907	10%	5,905	10%
		Minor Sloughs and Drains	Calculation	Estimated as zero	0	100%	0	100%
		Precipitation	Calculation	Quality-controlled precipitation from CIMIS, estimated canal surface area	418	15%	59	15%
		Shallow Groundwater Interception	Calculation	Estimated as closure of regional water balance. Distributed within region based on area, drain miles, and average depth to groundwater.	20,010	70%	20,391	70%
		Runoff of Precipitation	Calculation	IDC analysis, NRCS soils characteristics, CIMIS precipitation data	53,571	25%	5,674	25%
		Tailwater	Calculation	Estimated as 20% percent of Deliveries	83,308	30%	66,685	30%
	Outflow	**Deliveries (to Private Ditches and Farmed Lands)**	**Closure (Private Ditches and Farmed Lands)**	**Closure term of Private Ditches and Farmed Lands Water Balance**	**270,454**	**15%**	**216,422**	**12%**
		Evaporation	Calculation	CIMIS reference ET, estimated evaporation coefficient, estimated wetted surface area	955	15%	793	15%
		Riparian ET	Calculation	CIMIS reference ET, estimated crop coefficient based on 2009 SEBAL analysis, estimated riparian area	208	15%	159	15%
		Seepage	Calculation	NRCS soils data, published seepage rates by soil type, estimated wetted area, estimated wetted duration	10,210	35%	6,065	35%
		Butte Creek Spill	**Closure (District Distribution and Drainage System)**	**Difference between total inflows and measured/estimated outflows for District Distribution and Drainage System accounting center, distributed according to drainage area and available data, MBK 2003 Tailwater Study and Davids Engineering Boundary Outflow Monitoring from 2016 through 2019.**	**13,386**	**31%**	**6,967**	**43%**
		501 Main Drain			**12,315**		**6,410**	
		DD100 Drains			**10,939**		**5,694**	
		DD100 - Main Drain			**10,939**		**5,694**	
		Little Dry Creek			**24,796**		**12,906**	
		Cottonwood Creek			**9,116**		**4,745**	
		Subsurface Outflow to Butte Creek			**100,828**		**52,479**	
Private Ditches and Farmed Lands	Inflow	Precipitation	Calculation	Quality-controlled precipitation from CIMIS station, reported cropped area	107,501	15%	15,298	15%
		Deliveries	**Closure (Private Ditches and Farmed Lands)**	**Difference between measured/estimated inflows and total outflows for Privated Ditches and Farmed Lands accounting center, including estimated Tailwater as percentage of Deliveries**	**270,454**	**15%**	**216,422**	**12%**
		Shallow Groundwater Interception	Calculation	Estimated as closure of regional water balance. Distributed within region based on area, drain miles, and average depth to groundwater.	6,670	70%	6,797	70%
		Groundwater Pumping	Calculation	Estimated pumping based on estimated groundwater acres and associated applied water estimated from IDC.	9,237	25%	7,317	25%
	Outflow	Tailwater	Calculation	Estimated as 20% percent of Deliveries	83,308	30%	66,685	30%
		Crop ET of Applied Water	Calculation	CIMIS reference ET; estimated crop coefficients based on SEBAL 2009 analysis; crop acreages from WCWD records, DWR land use surveys, and agricultural commissioner crop reports; Integrated Water Flow Model Demand Calculator (IDC) analysis to divide total ET into applied water and precipitation components	170,113	10%	133,795	10%
		Crop ET of Precipitation	Calculation		39,877	10%	25,960	10%

Account-ing Center	Flow Path Type	Flow Path	Source	Supporting Data	Water Year (Oct. - Sept.)		Irrigation Season (Apr. - Sept.)	
					Average Volume (af)	Estimated Uncertainty	Average Volume (af)	Estimated Uncertainty
		Runoff of Precipitation	Calculation	IDC analysis, NRCS soils characteristics, CIMIS precipitation data	53,571	25%	5,674	25%
		Deep Percolation of Applied Water	Calculation	IDC analysis, NRCS soils characteristics, CIMIS precipitation data, Integrated Water Flow Model Demand Calculator (IDC) analysis to divide total deep perc. into applied water and precipitation components	37,786	35%	20,806	35%
		Deep Percolation of Precipitation	Calculation		9,639	35%	4,085	35%
	Change in Storage		Calculation	IDC Analysis	-432	50%	-11,170	50%

Table 7.5. Crop and Idle Acres, 1999-2019.

Year	Crop Acreage by Type					
	Rice	Orchards	Other	Idle	Total Cropped	Total with Idle
1999	48,344	1,472	2,972	2,763	52,787	55,551
2000	49,241	1,574	2,501	2,068	53,316	55,383
2001	42,256	1,784	3,223	7,257	47,263	54,519
2002	49,026	1,653	2,540	1,402	53,218	54,620
2003	42,845	1,680	1,639	8,895	46,164	55,060
2004	49,006	1,681	962	3,414	51,648	55,062
2005	48,692	1,634	1,290	2,768	51,616	54,384
2006	50,250	1,706	848	2,052	52,803	54,855
2007	50,515	1,727	927	1,462	53,169	54,631
2008	47,039	1,679	886	5,441	49,603	55,045
2009	50,078	1,667	897	2,242	52,642	54,884
2010	44,791	1,701	911	7,768	47,403	55,170
2011	51,524	1,724	1,066	237	54,314	54,552
2012	44,012	1,700	1,137	8,218	46,849	55,066
2013	51,969	1,650	1,030	29	54,648	54,676
2014	40,782	1,792	802	10,953	43,376	54,329
2015	44,198	2,125	675	5,464	46,998	52,462
2016	49,011	2,275	404	1,458	51,690	53,148
2017	40,894	2,275	404	9,575	43,572	53,148
2018	38,893	2,275	404	11,576	41,572	53,148
2019	45,203	2,275	404	5,267	47,881	53,148
Average	**46,598**	**1,812**	**1,234**	**4,777**	**49,644**	**54,421**

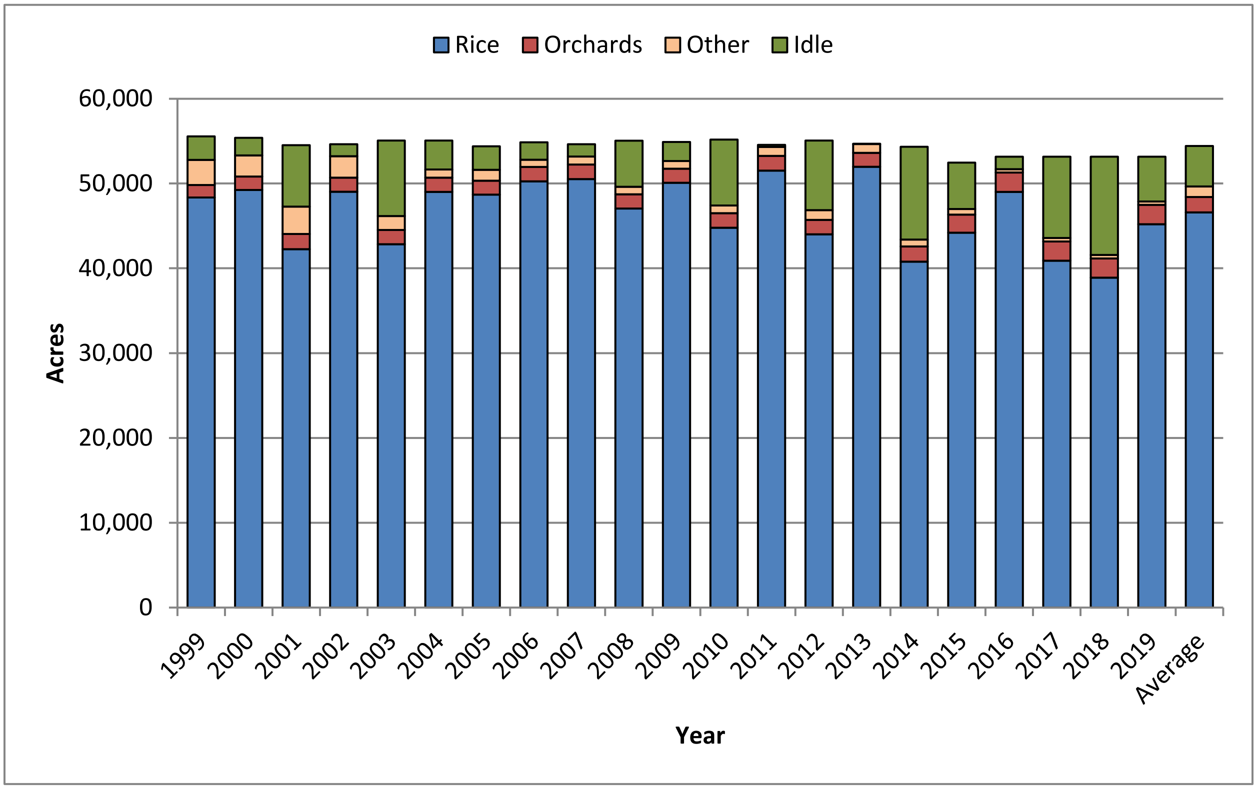


Figure 7.4. Crop and Idle Acres, 1999-2019[5]*.*

Crop evapotranspiration (ET) was estimated using a crop coefficient approach, whereby estimated crop- and time-specific water use coefficients were multiplied by reference ET (ET_o) to calculate the total consumptive use of water for the farmed lands over time. Crop coefficients specific to the Sacramento Valley were developed based on actual ET estimates from a remote sensing analysis using the Surface Energy Balance Algorithm for Land (SEBAL). The analysis used ground and satellite data to compute actual ET from March to September for individual 30-meter satellite pixels within Glenn and Colusa counties in 2009. Spatially distributed cropping data from DWR land use surveys for Glenn and Colusa counties for 2009 were combined with quality-controlled reference evapotranspiration (ET_o) from CIMIS to calculate crop coefficients representing actual ET over the course of the growing season[6]. A map showing March to September ET estimates for WCWD from SEBAL for 2009 is provided in Figure 7.5.

[5] Total acres vary somewhat from year to year reflecting estimated changes in total irrigable acres resulting from rural development and changes in areas of native vegetation.
[6] Ideally, the crop coefficient analysis would have included portions of Butte, Sutter, and Yuba counties within the Feather River region; however, DWR land use surveys were not available for 2009 for these counties. Crop coefficients developed for Glenn and Colusa counties are considered reasonably representative for the region as a whole.

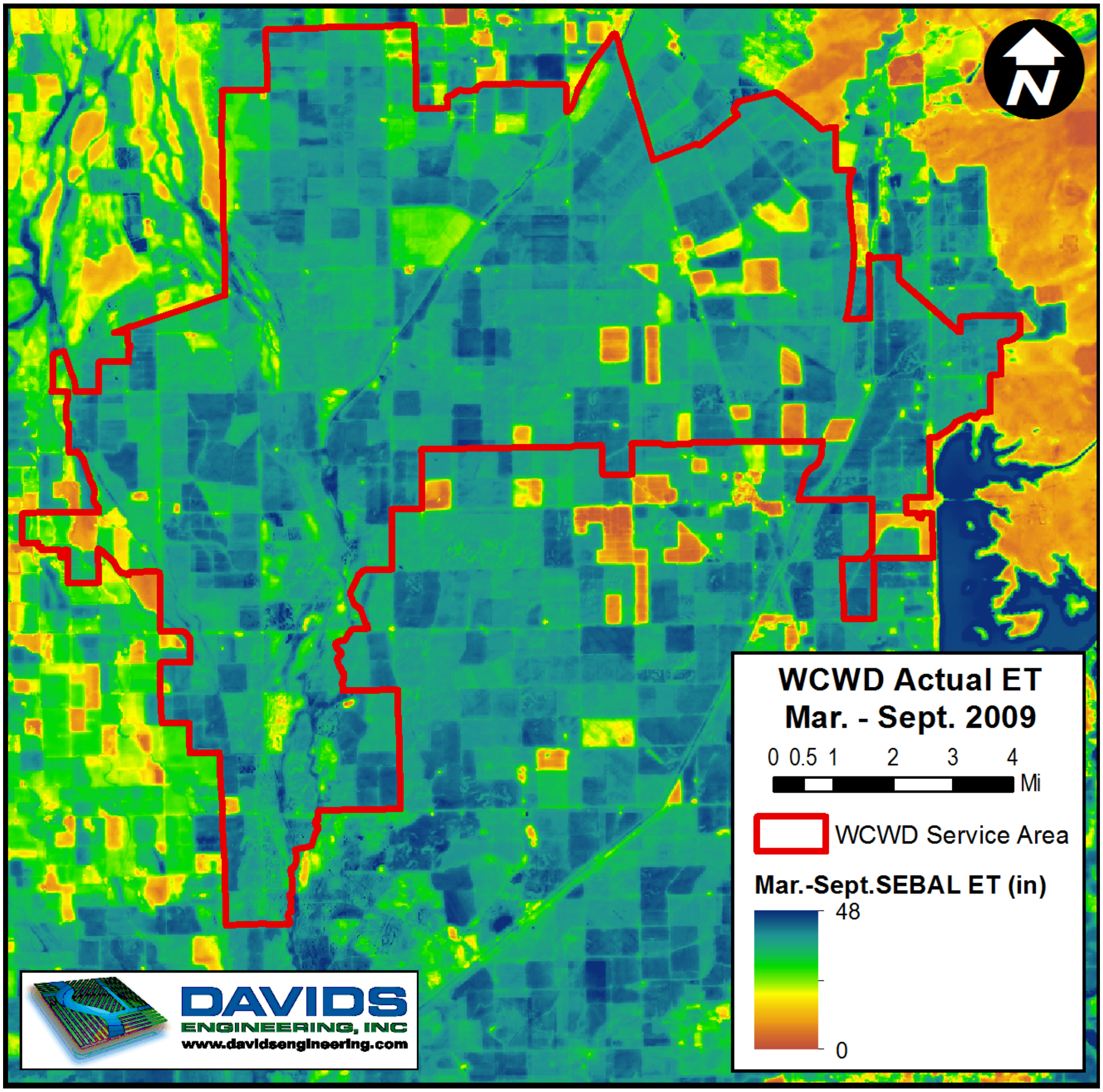


Figure 7.5. March to September 2009 SEBAL Actual ET.

A root zone water balance simulation was developed for each crop using the Integrated Water Flow Model (IWFM) Demand Calculator (IDC) Version 4.0 developed by DWR to estimate the portions of total ET derived from applied water (ET_{aw}) and from precipitation (ET_{pr}). ET values for each crop, expressed in units of acre-feet per acre were multiplied by the corresponding acreage in each year to compute total water volumes consumed for agricultural purposes.

For rice, the IDC model simulates ponding during the growing season and during the decomposition period in the fall and winter. As a result, precipitation occurring when ponds are full runs off of the fields and is not available to contribute to crop ET. Precipitation stored in the soil during the winter is available for extraction. For non-ponded crops, runoff and infiltration of precipitation are modeled for individual precipitation events. Precipitation entering the soil may be stored and available to support crop ET, or it may leave the root zone as deep percolation. One result of the differences in irrigation and cultural practices between rice and non-ponded crops is that ET_{pr} is significantly less for rice. Additional detail describing rice water management is provided in Volume I, Section 2.

Starting in 2015, water budget results presented in this AWMP are based on the Butte Basin Groundwater Model (BBGM) developed to support recent, local water management activities, including SGMA. The BBGM was developed using the latest available datasets including land use, precipitation, and actual evapotranspiration. Results from the BBGM for each land use category, expressed in units of acre-feet per acre, were multiplied by the corresponding acreage within the District's service area and incorporated into the District's water balance. Further information on the BBGM is available through Butte County's Department of Water and Resource Conservation.

The monthly consumptive use of water in WCWD ranges from approximately 1.2 inches of total ET in December and January to approximately 8.1 inches in June and July. A majority of ET is derived from applied water, and ET_{aw} ranges from approximately 0.9 inches in December and January to approximately 7.3 inches in July for the irrigable area. The average monthly consumptive use of water is presented in Figure 7.6.

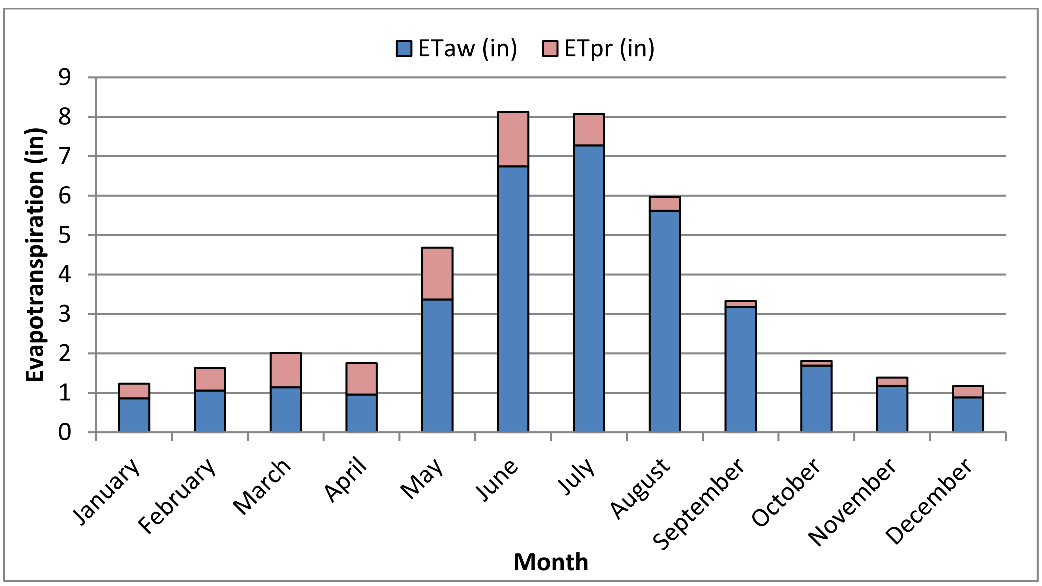


Figure 7.6. Average Monthly Consumptive Use of Water.

As indicated in Table 7.6, the annual consumptive use of water by crops in WCWD ranges from approximately 45 inches of total crop ET for rice to approximately 33 inches for other crops. ET_{aw} ranges from approximately 23 inches to 38 inches. For rice, approximately 39 inches of the 45 inches of total ET are derived from applied irrigation water. On average, approximately 34 inches of 41 inches of total ET are derived from applied irrigation water district-wide.

Table 7.6. Average Acreages and Annual Evapotranspiration Rates by Crop.

Crop	Average Acres	Average Evapotranspiration (in)		
		ET_c	ET_{aw}	ET_{pr}
Rice	46,598	45.1	38.4	6.8
Orchard	1,812	37.8	25.3	12.5
Other	1,234	33.1	23.4	9.7
Idle	4,777	11.4	1.1	10.3
Totals	**54,421**	**41.1**	**33.9**	**7.2**

ET_c and ET_{aw} vary from year to year due to differences in atmospheric water demand (ET_o) and differences in the timing and amount of precipitation available to support crop growth and offset crop irrigation requirements. Total annual ET varied between approximately 171,000 af and 248,000 af during the 1999 to 2019 period, with an average annual volume of 210,000 af. On average, approximately 170,000 af of ET were derived from applied irrigation water (81% of total ET) and 40,000 af of ET were derived from precipitation (19% of total ET).

Other uses of applied water include winter deliveries for habitat and rice straw decomposition (discussed in the following section). Due to the low salinity of surface water diverted from the Feather River, the required leaching fraction is assumed to be negligible for the crops grown in the District. Additionally, water applied for frost protection is also assumed to be negligible, based on the growing season and typical frost protection requirements of crops grown in WCWD (see Section 7.7.7).

Environmental and Recreational

Wetland and riparian habitat in WCWD comprise approximately 6,500 acres or 10% of lands within the district and include portions of the CDFW Upper Butte Basin Wildlife Area and the USFWS North Central Valley Wildlife Management Area. WCWD also provides water for habitat to a portion of the Llano Seco Unit of the Sacramento National Wildlife Refuge and to several private duck clubs both inside and outside of its boundary.

In addition to managed habitat, a majority of the rice fields in WCWD are currently flooded in the winter following harvest to aid in rice straw decomposition and to create winter habitat for migratory birds along the Pacific Flyway and other species. Use of water during the winter for rice decomposition and waterfowl habitat increased substantially between 1992 and 2001, largely driven by the phasing out of burning of rice straw as a result of the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 and has remained relatively steady since around 2000.

Estimated deliveries for managed wildlife habitat and rice straw decomposition within WCWD are provided in Table 7.7. These estimates are based on estimated deliveries from the water balance closure for the October to March period. Deliveries are typically near zero between February and March. In addition to deliveries for managed wetlands within WCWD, water is released to Butte Creek for use by duck clubs downstream of the District boundaries based on a 1922 agreement. These releases have been on the order of 15,000 to 30,000 af in recent years and were over 36,000 af in 2014.

Table 7.7. Estimated Winter Applied Water for Managed Habitat, Rice Straw Decomposition, and Butte Sink Duck Clubs.

Water Year	Applied Water (af)[1]	Butte Sink Duck Clubs (af)[2]	Total Winter Use (af)
1999	41,811	13,100	54,911
2000	54,503	22,840	77,343
2001	54,233	10,550	64,783
2002	58,444	18,100	76,544
2003	60,519	18,220	78,739
2004	52,254	11,350	63,604
2005	56,732	6,550	63,282
2006	52,196	11,850	64,046
2007	68,137	12,900	81,037
2008	61,674	13,000	74,674
2009	58,210	10,100	68,310
2010	52,981	13,850	66,831
2011	41,166	15,700	56,866
2012	55,204	26,000	81,204
2013	50,574	21,300	71,874
2014	74,028	36,450	110,478
2015	79,830	15,750	83,259
2016	33,197	22,350	33,968
2017	36,831	10,500	26,976
2018	54,438	12,100	44,898
2019	37,706	13,000	33,563
Average	**54,032**	**15,979**	**65,581**

1. Estimated based on water balance analysis. Includes metered deliveries plus reuse.

2. Based on recorded releases by WCWD to meet downstream demands. May differ from water balance estimates of total surface outflows.

The water supplied during the winter period provides critical habitat to support migratory waterfowl and shorebirds while also creating recreational opportunities. Aside from this, there are no recreational water uses within the district.

In addition to use of water within the district to provide winter habitat, surface outflows flow to Butte Creek, providing important flows to support migration of salmon and steelhead and other downstream uses of water for wildlife habitat, such as diversions by Sutter National Wildlife Refuge in the Sutter Bypass to support seasonal wetlands. Outflows from the WCWD service area are discussed in greater detail in the drainage and water accounting sections.

Municipal and Industrial

WCWD does not provide any municipal or industrial water.

Groundwater Recharge

Groundwater recharge that occurs within the district's service area consists of seepage from canals as well as deep percolation of precipitation and applied irrigation water. Distributed recharge through seepage and deep percolation provides a means to replenish the groundwater system to the benefit of WCWD water users, the community of Nelson, other individuals within WCWD, and surrounding areas overlying the Butte groundwater subbasin and Sacramento Valley groundwater basin.

Estimates of recharge were developed as part of the water balance analysis. Specifically, canal seepage estimates were calculated based on estimated soil hydraulic characteristics along with estimated canal wetted perimeters, overall lengths, and wetting frequency. Deep percolation of applied irrigation water and precipitation were calculated based on estimated applied irrigation water amounts over time as influenced by ET_0, precipitation, crop, and soil type, and simulated by the IDC model described previously.

Estimated annual seepage and deep percolation volumes for water years 1999 to 2019 are provided in Table 7.8, along with total recharge expressed as a volume and as a depth of water for each year.

Table 7.8. Total Groundwater Recharge, 1999-2019.

Water Year	Canal Seepage (af)	Deep Percolation of Applied Water (af)	Deep Percolation of Precipitation (af)	Total Recharge	
				af	af/ac
1999	10,877	36,879	10,190	57,947	1.1
2000	10,877	39,586	9,824	60,288	1.1
2001	10,877	36,875	7,774	55,527	1.2
2002	9,811	41,762	11,399	62,972	1.2
2003	10,877	35,554	11,538	57,969	1.3
2004	10,877	37,936	10,100	58,913	1.1
2005	10,877	39,338	12,286	62,501	1.2
2006	9,811	41,487	16,275	67,573	1.3
2007	10,877	40,454	3,272	54,604	1.0
2008	10,877	39,123	6,854	56,855	1.1
2009	10,877	39,141	4,799	54,817	1.0
2010	9,811	35,325	11,396	56,532	1.2
2011	9,811	39,857	17,542	67,210	1.2
2012	9,811	32,163	8,922	50,895	1.1
2013	10,877	38,714	5,999	55,590	1.0
2014	10,877	34,545	2,283	47,705	1.1
2015	9,242	33,849	6,410	49,501	1.1
2016	8,176	39,455	10,026	57,657	1.1
2017	8,887	38,682	15,882	63,451	1.5
2018	9,704	32,866	6,062	48,632	1.2
2019	9,704	39,910	13,580	63,194	1.3
Average	**10,210**	**37,786**	**9,639**	**57,635**	**1.2**

Total recharge between 1999 and 2019 ranged from approximately 48,000 af to 68,000 af per year, or from 1.0 af to 1.5 af per acre per year. On average between 1999 and 2019, total recharge was estimated to be approximately 58,000 af per year (1.2 af/ac), with approximately 18% of recharge originating from canal seepage, 66% from deep percolation of applied water, and 17% from deep percolation of precipitation.

Groundwater level monitoring data and field observations suggest that the shallow groundwater system and regional aquifer are coupled within portions of WCWD's service area at certain times and that an unsaturated aquifer zone may thus not be present to receive recharge. Depth to water in residential and irrigation wells is commonly less than five feet, and drains flow even when irrigation is not occurring. These conditions likely result from limited groundwater pumping in the area along with sustained use of surface water for irrigation over past decades. As a result, it is likely that a substantial portion of the water percolating into the soil from ponded fields and seeping from canals is unable to flow downward but rather flows horizontally to where it is intercepted by non-ponded vegetation or by drains, providing base flow. Shallow groundwater interception is shown conceptually in Figure 7.7 and discussed in a regional context in Volume I of this AWMP.

Even in areas where an unsaturated zone is present, water infiltrating into the soil in ponded fields may encounter impermeable layers caused by plow pan or natural soil features and flow laterally to adjacent lands or provide base flow for drains. Additional information is needed to distinguish shallow groundwater interception in areas where the shallow and regional groundwater systems are coupled from areas with perched shallow groundwater.

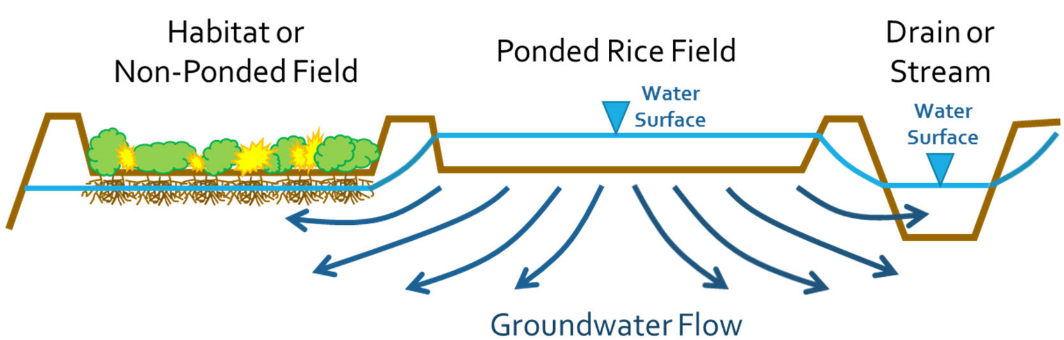


Figure 7.7. Conceptualization of Shallow Groundwater Interception in Rice Growing Areas.

Groundwater recharge net of well pumping and shallow groundwater interception represents the net amount of water contributing to groundwater storage from irrigation and precipitation processes in WCWD. Net recharge was calculated by subtracting estimated pumping volumes from total recharge volumes. As described above, shallow groundwater interception occurs when drains, creeks, or other waterways intercept or "gain" water from the shallow groundwater system, which may be perched or connected to the regional aquifer. Additionally, shallow groundwater can be intercepted and consumed by natural or other non-ponded vegetation. Net annual recharge estimates for 1999 to 2019 are provided in Table 7.9.

Table 7.9. Net Groundwater Recharge, 1999-2019.

Water Year	Total Recharge (af)	Groundwater Pumping (af)	Shallow Groundwater Interception (af)	Net Recharge	
				af	af/ac
1999	57,947	7,897	26,679	23,370	0.4
2000	60,288	8,180	26,679	25,428	0.5
2001	55,527	7,759	26,679	21,089	0.4
2002	62,972	8,516	26,679	27,777	0.5
2003	57,969	6,795	26,679	24,495	0.5
2004	58,913	7,613	26,679	24,621	0.5
2005	62,501	8,086	26,679	27,736	0.5
2006	67,573	7,194	26,679	33,700	0.6
2007	54,604	9,924	26,679	18,000	0.3
2008	56,855	8,840	26,679	21,336	0.4
2009	54,817	8,370	26,679	19,768	0.4
2010	56,532	6,590	26,679	23,263	0.5
2011	67,210	6,818	26,679	33,713	0.6
2012	50,895	7,484	26,679	16,732	0.4
2013	55,590	9,409	26,679	19,502	0.4
2014	47,705	8,004	26,679	13,021	0.3
2015	49,501	33,333	26,679	-10,511	-0.2
2016	57,657	13,498	26,679	17,480	0.3
2017	63,451	6,441	26,679	30,330	0.7
2018	48,632	6,339	26,679	15,614	0.4
2019	63,194	6,880	26,679	29,634	0.6
Average	**57,635**	**9,237**	**26,679**	**21,719**	**0.5**

Net recharge varied from approximately -11,000 af to 34,000 af per year between 1999 and 2019, or -0.2 af to 0.7 af per acre per year. On average between 1999 and 2019, net recharge was estimated to be approximately 22,000 af per year (0.5 af/ac-year). The only year in which net recharge was negative during this period was 2015.

Transfers and Exchanges

The district participated in seven voluntary water transfers between in 1999 and 2019. All transfers were crop idling-based. Participating landowners idled land within the district and transferred the surface water that would have been consumed in lieu of the transfer. The quantity of water transferred was based on DWR estimates of the annual evapotranspiration of applied water for rice (3.3 af/ac). Estimates of idled acres and the amount of water transferred each year are provided in Table 7.10.

Table 7.10. Crop Idling Water Transfer Volumes, 1999-2019.

Year	Idle Acreage	Transfer Volume (af)
2001	5,077	16,754
2003	6,060	19,998
2008	4,517	14,906
2009	1,844	6,085
2010	7,444	24,565
2012	8,193	27,037
2014	10,740	35,442
2018	10,344	34,135

Other Water Uses

Other incidental uses of water within WCWD may include watering of roads for dust abatement or agricultural spraying. The volume of water used for such purposes is small relative to other uses and, thus, not itemized, but is accounted for in the water budget as part of the volume of deliveries to farmed lands.

7.7.4 Drainage

Surface Outflows

Surface drains within WCWD convey runoff of precipitation, surface inflows from upgradient lands, runoff of irrigation water (tailwater), and provide shallow groundwater relief by capturing canal seepage and intercepting shallow groundwater. Surface drains are also an important source of water for crop season irrigation and winter flooding in certain areas. All water leaving the district as surface outflow is available for downstream agricultural and environmental uses. Annual surface outflows are summarized in Table 7.11. Surface outflows during the irrigation season are approximately half of annual values.

Water year boundary outflows ranged from approximately 137,000 af to 252,000 af between 1999 and 2019 with an average of 182,000 af. Based primarily on estimated tributary areas above each outflow location, total boundary outflows were divided among the primary outflows.

Table 7.11. Estimated Surface Outflow Volumes, 1999-2019.

Water Year	Butte Creek Spill (af)	501 Main Drain (af)	DD100 Drains (af)	DD100-Main Drain (af)	Little Dry Creek (af)	Cotton wood Creek (af)	Subsurface Outflow to Butte Creek (af)	Total Boundary Outflows (af)
1999	11,680	10,746	9,545	9,545	21,636	7,954	87,982	159,090
2000	14,653	13,481	11,975	11,975	27,143	9,979	110,374	199,580
2001	11,837	10,890	9,673	9,673	21,926	8,061	89,158	161,217
2002	12,109	11,140	9,896	9,896	22,431	8,246	91,211	164,929
2003	11,932	10,978	9,751	9,751	22,103	8,126	89,880	162,523
2004	16,347	15,039	13,359	13,359	30,281	11,132	123,132	222,649
2005	12,224	11,247	9,990	9,990	22,644	8,325	92,080	166,500
2006	15,466	14,229	12,639	12,639	28,649	10,533	116,499	210,655
2007	10,264	9,443	8,388	8,388	19,013	6,990	77,313	139,799
2008	12,701	11,685	10,379	10,379	23,527	8,649	95,669	172,989
2009	12,595	11,587	10,292	10,292	23,330	8,577	94,868	171,541
2010	15,021	13,819	12,275	12,275	27,825	10,230	113,145	204,591
2011	16,235	14,937	13,268	13,268	30,074	11,056	122,292	221,130
2012	13,074	12,028	10,684	10,684	24,217	8,903	98,475	178,064
2013	10,560	9,715	8,630	8,630	19,561	7,191	79,541	143,827
2014	10,976	10,098	8,969	8,969	20,331	7,474	82,673	149,490
2015	10,056	9,251	8,218	8,218	18,627	6,848	75,743	136,960
2016	13,199	12,143	10,786	10,786	24,449	8,988	99,417	179,767
2017	18,467	16,990	15,092	15,092	34,208	12,576	139,102	251,526
2018	14,161	13,028	11,572	11,572	26,231	9,643	106,663	192,870
2019	17,548	16,144	14,340	14,340	32,505	11,950	132,178	239,005
Average	**13,386**	**12,315**	**10,939**	**10,939**	**24,796**	**9,116**	**100,828**	**182,319**

Tailwater

The farmed lands water balance includes an estimate of the volume of tailwater entering the distribution and drainage system that is available for reuse. A portion of this volume is reused within the district and is included in the estimated deliveries; the remainder is available for reuse by downgradient water users in RID, along Butte Creek, in the Butte Sink, in the Sutter Bypass, etc. Table 7.12 presents the estimated annual tailwater volumes between water years 1999 and 2019.

Tailwater entering the distribution and drainage system between 1999 and 2019 ranged from approximately 66,000 af to 100,000 af per year. The average tailwater volume for this period was approximately 83,000 af per year.

Reuse

WCWD recovers operational spillage and tailwater via gravity at two locations in the distribution system. First, the Fenn drain conveys upstream operational spillage and tailwater to the Main Canal upstream of the “reservoir” at Little Butte Creek. Second, the control structure on the 501 Main Drain allows the upstream water level to be raised so that water can be delivered from the drain to Howard Slough for downstream use via the Howard Slough headgates.

Table 7.12. Estimated Tailwater Volumes, 1999-2019.

Water Year	Tailwater (af)
1999	81,768
2000	87,675
2001	84,224
2002	90,484
2003	77,752
2004	79,130
2005	82,165
2006	80,066
2007	100,487
2008	92,192
2009	89,055
2010	75,077
2011	74,028
2012	76,202
2013	91,699
2014	81,005
2015	66,472
2016	84,337
2017	85,258
2018	96,714
2019	73,672
Average	**83,308**

Based on comparison of WCWD total measured deliveries for 2008 through 2012 to deliveries calculated from the water balance analysis, which include district and private reuse, it is estimated that approximately 18 percent of the calculated deliveries represent reuse, or approximately 50,000 af annually. It is assumed that approximately one third of the total reuse results from recapture of spillage and tailwater by the district, with the remaining two thirds resulting from recapture by individual water users. Reuse by WCWD and individual water users reduces diversion requirements from the afterbay and results in district-scale water use efficiency that would otherwise not be attained. Implications of reuse at the district and regional scales are further discussed in the following section.

7.7.5 Water Accounting (Summary of Water Balance Results)

The WCWD water balance structure was shown previously in Figure 7.3. The water balance was prepared for the distribution and drainage system and for farmed lands. Additionally, the water balance can be summarized for the WCWD service area as a whole ("Water Balance Boundary" shown in Figure 7.3). An accounting center representing the groundwater system is also included in Figure 7.3 to account for exchanges between the root zone and the underlying groundwater system; however, a complete balance for the underlying aquifer has not been developed because not all inflows and outflows into the groundwater system (such as horizontal boundary flows) have been estimated.

As depicted in Figure 7.3 and discussed previously, interconnection exists between the accounting centers due to recapture and reuse of water by both WCWD and by individual water users. Specifically, surface runoff of applied water (tailwater) flows back into the distribution and drainage system. Within the drainage system, reuse of tailwater, operational spillage, or water from other sources is practiced by the district and by individual water users. This water recovery and reuse results in higher levels of aggregate performance than would otherwise occur.

The water balance results are presented on a water year basis for 1999 through 2019. Underlying the annual time step is a more detailed water balance in which all flow paths are estimated on a monthly basis.

District-Wide and Individual Accounting Center Water Balance Results

A district-wide water balance combining individual inflows and outflows into general categories is shown in Figure 7.8 for the water year and for the April to September primary irrigation season. In each figure, average volumes are presented for each inflow and outflow category, as well as average volumes expressed in acre-feet per acre. Average monthly inflows to and outflows from WCWD are further summarized in Figures 7.9 and 7.10, respectively.

Detailed annual water balance results for the distribution and drainage system are summarized in Table 7.13. Detailed annual water balance results for the farmed lands are summarized in Table 7.14. In each table, performance indicators discussed in the following section are provided.

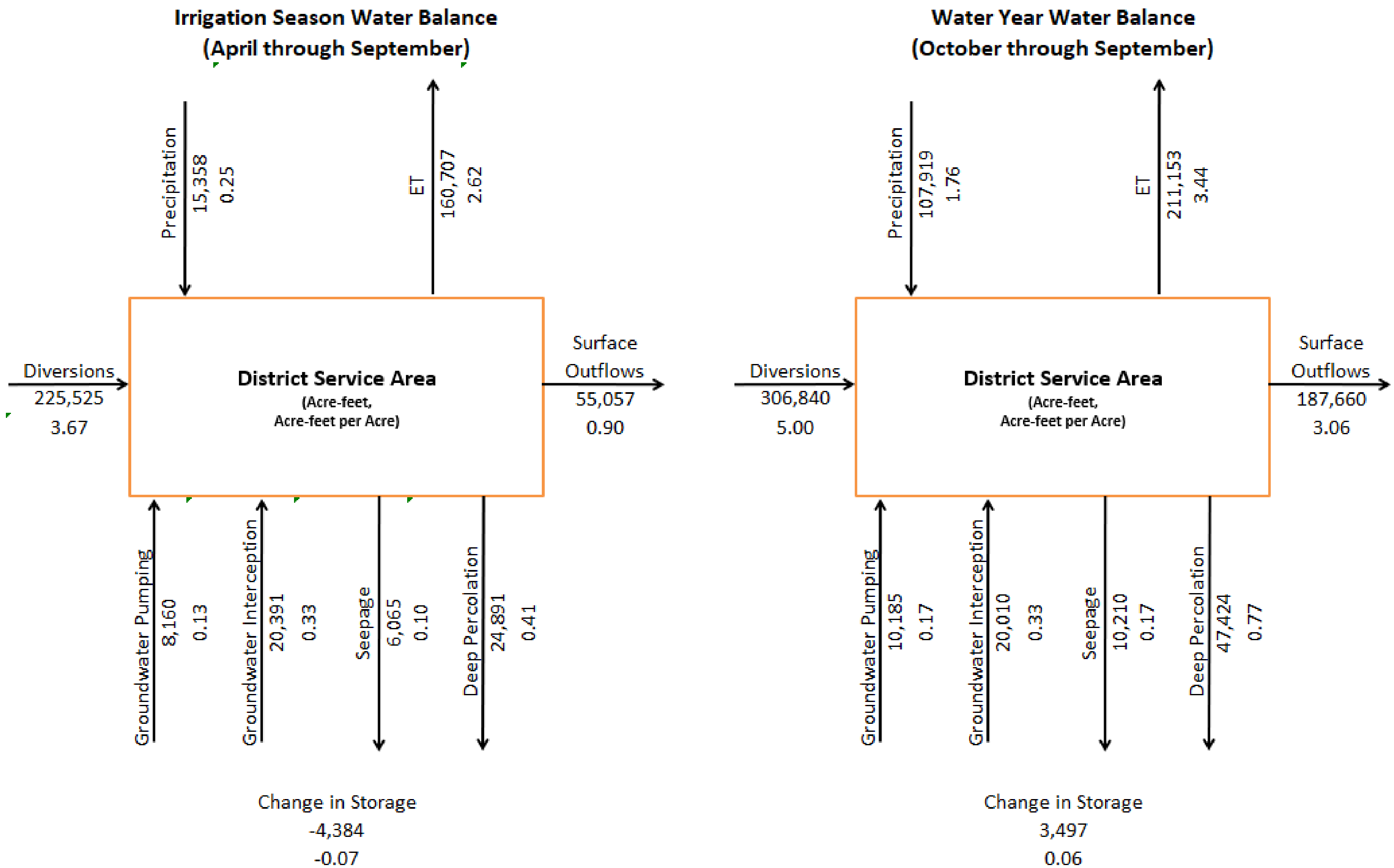


Figure 7.8. Average District Water Balance, 1999-2019.

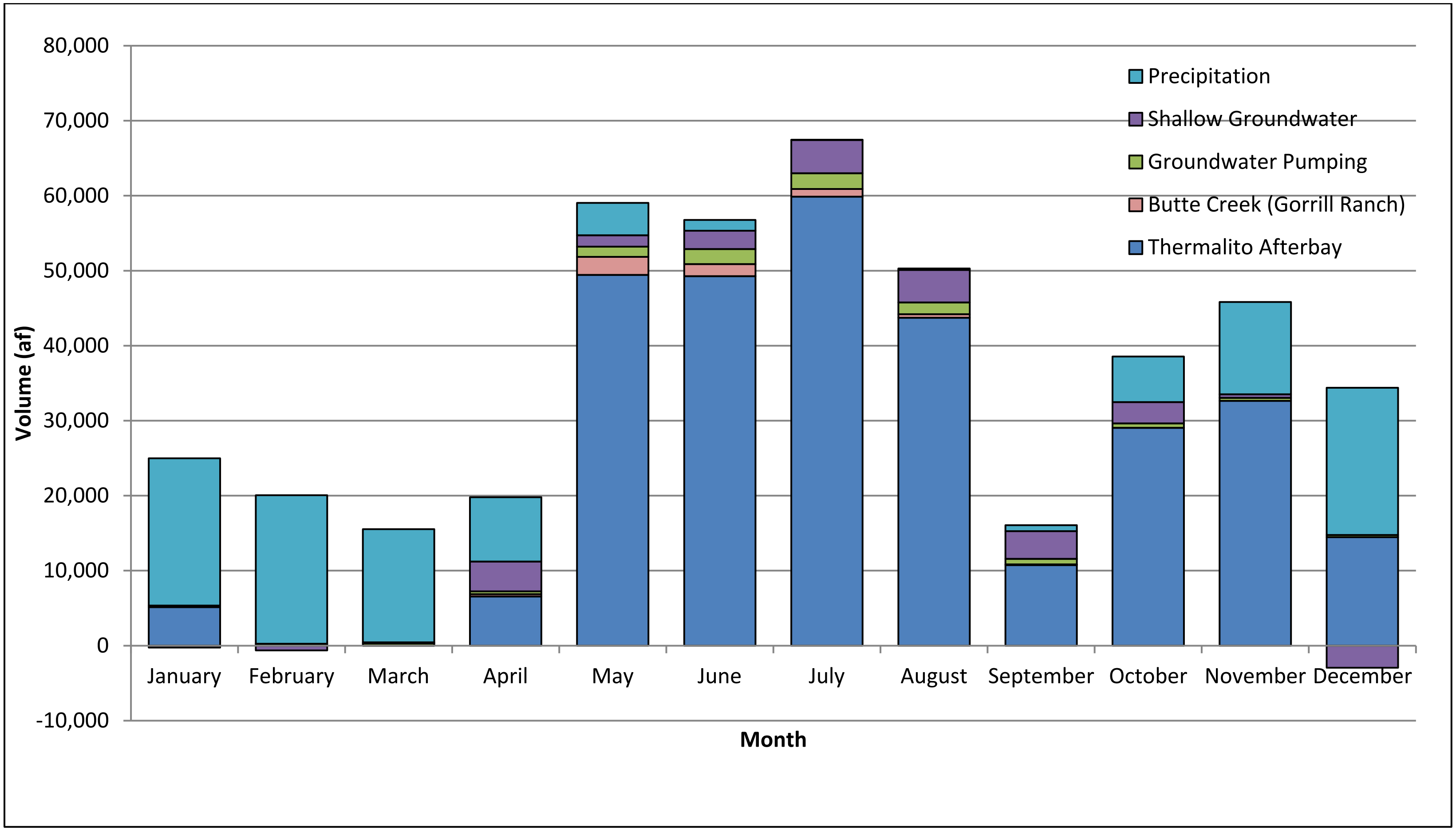


Figure 7.9. Average Monthly Inflows, 1999-2019.

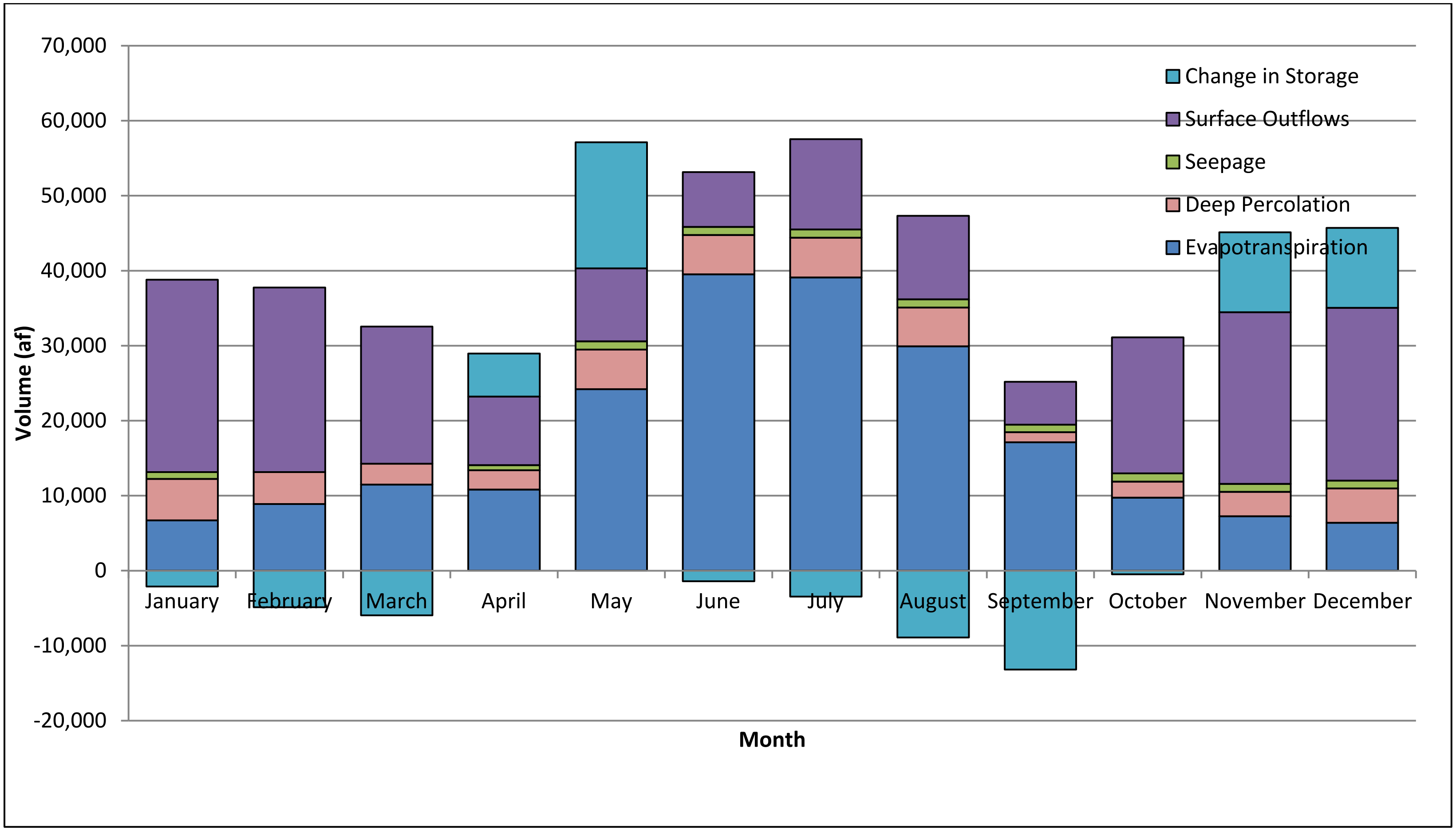


Figure 7.10. Average Monthly Outflows and Change in Storage, 1999-2019.

Table 7.13. Distribution and Drainage System Annual Water Balance Results, 1999-2019.

Water Year	Inflows (af)								Outflows (af)					Performance Indicators	
	Western Main Canal Diversion	374 Lateral Diversion	Gorrill Ranch Diversion	Precipitation	Shallow Groundwater Interception	Minor Sloughs and Drains	$Runoff_{pr}$	Tailwater	Deliveries	Seepage	Riparian ET	Evaporation	Boundary Outflows	Delivery Fraction	Water Management Fraction
1999	289,095	4,332	13,463	350	20,010	0	34,678	81,768	272,561	10,877	205	963	**159,090**	0.89	0.998
2000	321,352	4,050	9,197	459	20,010	0	61,189	87,675	292,251	10,877	213	1,011	**199,580**	0.87	0.998
2001	298,505	4,304	7,567	358	20,010	0	39,131	84,224	280,748	10,877	218	1,038	**161,217**	0.90	0.998
2002	300,986	4,515	6,526	425	20,010	0	54,552	90,484	301,614	9,811	218	925	**164,929**	0.97	0.998
2003	257,119	4,076	8,965	501	20,010	0	65,337	77,752	259,173	10,877	200	986	**162,523**	0.96	0.998
2004	325,402	4,325	9,658	409	20,010	0	59,574	79,130	263,768	10,877	196	1,018	**222,649**	0.78	0.998
2005	280,303	3,901	7,482	492	20,010	0	58,026	82,165	273,882	10,877	202	918	**166,500**	0.94	0.998
2006	291,042	3,939	8,240	597	20,010	0	84,532	80,066	266,886	9,811	193	881	**210,655**	0.88	0.998
2007	332,607	4,113	4,370	257	20,010	0	25,024	100,487	334,955	10,877	231	1,004	**139,799**	0.98	0.998
2008	330,411	3,289	5,295	326	20,010	0	40,869	92,192	307,305	10,877	226	992	**172,989**	0.91	0.998
2009	325,619	3,101	5,981	320	20,010	0	36,319	89,055	296,849	10,877	210	927	**171,541**	0.89	0.998
2010	309,798	4,091	6,357	449	20,010	0	49,914	75,077	250,255	9,811	195	842	**204,591**	0.78	0.998
2011	289,878	3,795	10,289	609	20,010	0	80,050	74,028	246,759	9,811	189	770	**221,130**	0.81	0.998
2012	306,572	2,924	5,403	361	20,010	0	31,501	76,202	254,008	9,811	211	880	**178,064**	0.81	0.998
2013	320,442	3,799	2,289	269	20,010	0	23,112	91,699	305,664	10,877	215	1,035	**143,827**	0.94	0.998
2014	315,985	3,236	650	158	20,010	0	10,609	81,005	270,016	10,877	220	1,050	**149,490**	0.84	0.998
2015	247,415	2,654	0	267	20,010	0	32,134	66,472	221,573	9,242	201	975	**136,960**	0.89	0.997
2016	279,154	3,711	2,176	432	20,010	0	62,843	84,337	263,554	8,176	210	957	**179,767**	0.92	0.998
2017	259,765	3,413	4,729	712	20,010	0	118,001	85,258	230,351	8,887	197	926	**251,526**	0.86	0.998
2018	280,596	3,600	3,233	352	20,010	0	41,048	96,714	241,785	9,704	208	985	**192,870**	0.84	0.998
2019	278,025	4,360	2,176	671	20,010	0	116,543	73,672	245,573	9,704	204	971	**239,005**	0.86	0.998
Minimum	247,415	2,654	0	158	20,010	0	10,609	66,472	221,573	8,176	189	770	**136,960**	0.78	0.997
Maximum	332,607	4,515	13,463	712	20,010	0	118,001	100,487	334,955	10,877	231	1,050	**251,526**	0.98	0.998
Average	297,146	3,787	5,907	418	20,010	0	53,571	83,308	270,454	10,210	208	955	**182,319**	0.88	0.998

Table 7.14. Farmed Lands Annual Water Balance Results, 1999-2019.

Water Year	Inflows (af)				Outflows (af)						Change in Storage (af)	Performance Indicators		
	Deliveries	Precipitation	Shallow Groundwater Interception	Groundwater Pumping	Evapotranspiration of Applied Water	Evapotranspiration of Precipitation	Deep Percolation of Applied Water	Deep Percolation of Precipitation	Runoff of Precipitation	Tailwater		Deliveries (af/ac)	Surface Water Supply Fraction	Crop Consumptive Use Fraction
1999	272,561	89,625	6,670	7,897	174,788	44,417	36,879	10,190	34,678	81,768	-5,969	4.54	0.97	0.62
2000	292,251	117,770	6,670	8,180	186,442	41,658	39,586	9,824	61,189	87,675	-1,504	4.83	0.97	0.62
2001	280,748	91,445	6,670	7,759	177,693	40,247	36,875	7,774	39,131	84,224	678	5.12	0.97	0.62
2002	301,614	108,884	6,670	8,516	193,609	39,555	41,762	11,399	54,552	90,484	-5,676	4.98	0.97	0.62
2003	259,173	128,310	6,670	6,795	155,594	45,790	35,554	11,538	65,337	77,752	9,384	4.86	0.97	0.59
2004	263,768	104,745	6,670	7,613	175,397	32,474	37,936	10,100	59,574	79,130	-11,815	4.51	0.97	0.65
2005	273,882	126,103	6,670	8,086	166,980	47,272	39,338	12,286	58,026	82,165	8,675	4.68	0.97	0.59
2006	266,886	152,924	6,670	7,194	163,488	45,233	41,487	16,275	84,532	80,066	2,593	4.49	0.97	0.60
2007	334,955	65,618	6,670	9,924	214,396	34,051	40,454	3,272	25,024	100,487	-517	5.62	0.97	0.62
2008	307,305	83,278	6,670	8,840	197,828	34,521	39,123	6,854	40,869	92,192	-5,294	5.51	0.97	0.63
2009	296,849	81,788	6,670	8,370	189,401	34,893	39,141	4,799	36,319	89,055	69	5.07	0.97	0.62
2010	250,255	114,789	6,670	6,590	150,852	46,392	35,325	11,396	49,914	75,077	9,349	4.71	0.97	0.59
2011	246,759	156,015	6,670	6,818	157,211	51,076	39,857	17,542	80,050	74,028	-3,503	4.10	0.97	0.62
2012	254,008	92,494	6,670	7,484	161,902	49,346	32,163	8,922	31,501	76,202	620	4.84	0.97	0.62
2013	305,664	68,709	6,670	9,409	201,639	33,410	38,714	5,999	23,112	91,699	-4,121	5.06	0.97	0.64
2014	270,016	40,232	6,670	8,004	171,540	25,794	34,545	2,283	10,609	81,005	-855	5.49	0.97	0.62
2015	221,573	69,507	6,670	33,333	147,532	32,088	33,849	6,410	32,134	66,472	12,599	4.22	0.87	0.58
2016	263,554	116,031	6,670	13,498	164,761	39,729	39,455	10,026	62,843	84,337	-1,399	5.10	0.95	0.59
2017	230,351	187,255	6,670	6,441	138,034	43,245	38,682	15,882	118,001	85,258	-8,384	5.29	0.97	0.58
2018	241,785	86,903	6,670	6,339	135,847	34,835	32,866	6,062	41,048	96,714	-5,675	5.82	0.97	0.55
2019	245,573	175,090	6,670	6,880	147,449	41,383	39,910	13,580	116,543	73,672	1,677	5.13	0.97	0.58
Minimum	221,573	40,232	6,670	6,339	135,847	25,794	32,163	2,283	10,609	66,472	-11,815	4.10	0.87	0.55
Maximum	334,955	187,255	6,670	33,333	214,396	51,076	41,762	17,542	118,001	100,487	12,599	5.82	0.97	0.65
Average	270,454	107,501	6,670	9,237	170,113	39,877	37,786	9,639	53,571	83,308	-432	5.77	0.97	0.61

Characterization of Water Management and Performance

District

Monthly inflow and outflow patterns provide insight into water management at the district-scale, which is heavily influenced by water management for rice. The observed monthly patterns likely differ from individual fields, and reflect the full population of fields in the district.

Diversions begin in April or May and continue at relatively steady levels through August, decreasing in September as fields are drained for harvest. In October and November diversions again increase and continue through December to flood fields for rice straw decomposition and habitat. Diversions cease in January in preparation for the next year's crop.

Monthly ET generally follows the pattern of ET_o, increasing in the spring and summer as temperatures and available solar radiation increase and then decreasing in the winter. Actual ET rates are relatively similar to reference values due to the availability of adequate surface water supplies to support crop growth and relatively moist conditions throughout the growing season. Deep percolation and seepage are relatively constant over time due to the use of available surface water during the majority of the year, with deep percolation increasing somewhat in the winter as a result of precipitation and decreasing prior to planting and following harvest as a result of dry conditions. Surface outflows follow the general pattern of diversions, increasing during irrigation and winter flooding as a result of both irrigation and precipitation processes.

The monthly change in storage reflects rice growing and winter flooding as well, with water going into storage in April and May, remaining relatively constant in June and July, and coming out of storage as fields are drained in August and September. Storage then increases again October through December due to winter flooding and decreases in January through March in preparation for planting.

On a water year basis, substantial recharge of the groundwater system occurs as a result of the use of surface water within WCWD. It is estimated that approximately 21,000 af of groundwater recharge net of groundwater pumping and shallow groundwater interception occur annually within the district. Net recharge is somewhat limited due to shallow groundwater conditions in WCWD resulting in part from historical use of surface water and limited pumping. Approximately 27,000 af of shallow groundwater interception occurs annually. Groundwater interception supports the growth of native vegetation and provides base flow for streams and drains.

Comparing total inflows to WCWD to total outflows to meet consumptive irrigation demands plus recoverable flows available for use by others or the environment, a Water Management Fraction (WMF) may be calculated[7]. This indicator describes the amount of the total water supply not lost irrecoverably to evaporation from the canal and drain system (Equation 7.2).

[7] The WMF is based on methodologies to quantify the efficiency of agricultural water use developed by DWR (DWR 2012b) and has been broadened to include all beneficial ET as well as all water supplies.

$$Water\ Management\ Fraction = \frac{Evapotranspiration + Recoverable\ Flows}{Inflows} \quad [7.2]$$

Over the period from 1999 to 2019, the average WMF was 0.998, indicating that essentially all available water supply is used to meet irrigation demands or is recoverable for downstream surface water and groundwater uses.

Distribution and Drainage System

Inflows to the distribution and drainage system in the WCWD service area include diversions from the Thermalito Afterbay via the Western Main Canal and 374 Lateral; Gorrill Ranch diversions from Butte Creek; precipitation falling directly into canals and drains; runoff of precipitation from farmed lands; shallow groundwater interception; and tailwater inflows from farmed lands. Outflows include deliveries; surface outflows through the Butte Creek Spill, 501 Main Drain, DD100 drains, Little Dry Creek, and Cottonwood Creek; seepage; evaporation; and riparian ET.

The objective of WCWD operations is to meet the irrigation and environmental water demands of its customers. The water balance results indicate several characteristics of water management by WCWD and its customers. Comparing total deliveries to meet irrigation demand to diversions provides a measure of the effectiveness of system operation. A Delivery Fraction (DF), representing the ratio of deliveries to diversions may be calculated to provide an indicator of distribution and drainage system performance (Equation 7.3)[8].

$$Delivery\ Fraction = Deliveries/Diversions \quad [7.3]$$

The DF ranged from 0.78 to 0.98 between 1999 and 2019 with an overall average of 0.88. DF values increase as a result of limiting operational spillage and through recovery and reuse of available water in the system by WCWD and individual water users.

Farmed Lands

Inflows to the farmed lands include deliveries[9], groundwater pumping from private wells, and precipitation. Outflows include ET, tailwater, runoff of precipitation, and deep percolation. Additionally, as discussed previously, appreciable changes in stored water in the surface layer occur within the district as a result of rice production and winter flooding.

The objective of irrigation in WCWD is to meet crop and environmental water demands in the most effective and efficient manner practical. Like the distribution and drainage system water balance, the farmed lands water balance provides insight into water management by WCWD and growers.

[8] Although the surface water supply includes sources other than diversions (e.g., precipitation inflows), the DF is calculated to include only diversions as this is the portion of surface water supply directly managed by WCWD.

[9] As described previously, deliveries include direct deliveries by WCWD and reuse by WCWD and individual water users.

Comparing total surface water supply (other than precipitation falling on farmed lands) to total irrigation supply including groundwater pumping, a surface water supply fraction (SWSF) may be calculated as an indicator of the relative amount of the total irrigation supply derived from surface water (Equation 7.4).

$$Surface\ Water\ Supply\ Fraction = Deliveries\ /\ (Deliveries + Groundwater\ Pumping) \quad [7.4]$$

The SWSF was approximately 0.97 between 1999 and 2019, demonstrating the reliability of and reliance on surface water supplies within WCWD. In the event of reduced surface water allocations due to surface water shortages, private groundwater pumping can be increased to some extent to minimize lost production, resulting in decreased SWSF for those years. The SWSF in 2015 was 0.87, and it is estimated that the SWSF in the shortage years of 1991 and 1992 was approximately 0.81; this indicates that surface water is the primary water source to meet demands even in years of reduced supply.

Comparing crop ET_{aw} to total irrigation supplies, a crop consumptive use fraction (CCUF) may be calculated as an indicator of the relative amount of applied irrigation water consumed to grow the crop (Equation 7.5) (DWR 2012b).

$$Crop\ Consumptive\ Use\ Fraction = Crop\ ET\ of\ Applied\ Water\ /\ (Deliveries + Groundwater\ Pumping) \quad [7.5]$$

Between 1999 and 2019, the CCUF ranged from 0.55 to 0.65 with an overall average of 0.61. These CCUF values are calculated at the field scale and thus are not reflective of water reuse within the district. Based on estimated reuse of approximately 16,000 af of surface water by the district annually and 33,000 af of private reuse, the average CCUF at the district scale is estimated to be 0.73[10].

7.7.6 Water Management Objectives

Water management objectives (WMOs) vary depending on perspective. From a local, agricultural perspective, the objective of a water supplier is to provide water to customers for irrigation in a manner that supports optimal crop production. From a regional and statewide perspective, WMOs encompass broader goals to support long-term reliability of water supply, and to provide instream flows that benefit aquatic ecosystems.

WCWD's WMOs are to support the long term reliability, quality, and affordability of local surface water and groundwater supplies, and to provide the best service practical to the water users it supplies. WCWD is implementing a number of actions to support these WMOs, including:

- Implementation of a volumetric water rate to encourage on-farm water use efficiency
- Conjunctive management of surface water and groundwater to support the long-term reliability and quality of water supplies

[10] Estimated as annual ET_{aw}/(deliveries + groundwater pumping – district reuse*DF – other reuse).

- Implementing new technology to increase operational efficiency, including a:
    - Comprehensive water information system (WIS) that improves overall system management and incorporates tools for operational staff to support increased operational efficiency
    - FLOW Portal, an online platform that gives growers access to their delivery flow measurements in real-time in an effort to reduce farm tailwater

Section 7.9, "Efficient Water Management Practices and Water Use Efficiency," describes other actions that WCWD is doing, or planning to do in the coming years, to improve water system management, reduce water loss, and meet the District's management objectives.

The local, regional, and statewide WMOs that apply to the Feather River region as a whole are described in Volume I, Section 4.4 of this regional AWMP. Many WMOs are widely applicable due to the similarity in the nature of diversion agreements with the State among the primary water suppliers relying on the Feather River, and due to similarity in cropping and other factors that impact water uses and water system efficiency.

7.7.7 Water Use Efficiency

Water use efficiency is a core consideration in WCWD's operations. As stated above, WCWD's objectives are to support the long term reliability, quality, and affordability of local surface water and groundwater supplies, and to provide the best service practical to the water users it supplies. Efficient water use at all levels benefits this mission by conserving or utilizing water for maximal benefit to WCWD's customers, the environment, and downstream water users.

Key water use components and water use efficiency in WCWD are quantified in the sections below.

Water Use Efficiency Components

Four types of water use serve as the basis for water use efficiency calculations: crop water use, agronomic water use, environmental water use, and recoverable flows. These water use efficiency components are quantified in Table 7.15, and are described in the sections below.

<u>Crop Water Use</u>

Crop water use, or crop consumptive use, represents the portion of total applied water withdrawn by crops that is evaporated, transpired, incorporated into products or crops, or otherwise removed from the immediate water environment for consumptive use (ASCE, 2016).

In the water budget presented in this AWMP, crop water use of applied water is referred to as evapotranspiration of applied water (ET_{aw}). ET_{aw} is quantified as a portion of total crop ET using the IDC root zone water budget model, as described above in Section 7.7.3. Table 7.15 summarizes the ET_{aw} in WCWD in the last five water years (2015-2019). In addition to ET_{aw} from farmed lands, a small amount of riparian evapotranspiration is included (approximately 200 af per year).

Table 7.15. Water Use Efficiency Components.

Water Use Efficiency Component	Water Year Volume (Surface Water Allotment), af/year					
	2015 (Curtailed)	2016 (Full)	2017 (Full)	2018 (Full)	2019 (Full)	Average
Crop Consumptive Use (ET_{aw}, Riparian ET[1])	147,733	164,970	138,230	136,056	147,653	**146,928**
Agronomic Use[2]	67,509	11,618	16,476	32,798	20,563	**29,793**
Environmental Use[3]	15,750	22,350	10,500	12,100	13,000	**14,740**
Recoverable Flows of Total Water Supply						
Recoverable Surface Flows (Deliveries Less ET_{aw}[4], Boundary Outflows)	227,392	269,476	334,630	296,984	344,201	**294,537**
Other Recoverable Flows (Canal Seepage)	9,242	8,176	8,887	9,704	9,704	**9,143**
Total Recoverable Flows	236,634	277,651	343,517	306,689	353,905	**303,679**

[1] In additional to crop consumptive use, a small amount of water is consumptively used by riparian vegetation (approximately 200 af per year).
[2] Agronomic use for rice straw decomposition.
[3] Winter deliveries for managed wildlife habitat.
[4] Applied irrigation water is either consumptively used by crops as ET_{aw}, or available as recoverable flows to surface water (tailwater) or as recoverable flows to groundwater (deep percolation of applied water). As some water is reused internally within the WCWD canals to support deliveries, the total deliveries (less ET_{aw}) are summarized under recoverable surface flows.

Agronomic Water Use

Agronomic water use in WCWD represents the portion of total applied water that is directly used for crop cultivation practices, but that is not consumed by crops (i.e., excluding ET_{aw}). Sample agronomic water uses include water used for seedbed preparation, pest control, salt leaching, and climate control.

In WCWD, agronomic water use mainly includes winter deliveries for rice straw decomposition. A majority of the rice fields in WCWD are flooded following harvest to aid in rice straw decomposition. The volume of applied water that is used to support this agronomic purpose is estimated as the deliveries and reuse during the October to March period, calculated as the water balance closure in those months. Deliveries are typically near zero between February and March. These deliveries also help to create winter habitat for migratory birds and other species along the Pacific Flyway. The estimated agronomic water uses for rice straw decomposition are summarized in Table 7.15.

Surface water diverted from the Feather River is of very high quality, with low salinity and low TDS, resulting in generally low leaching requirements for the crops grown in the District. Considering the low salinity of surface water supplied by WCWD, the leaching that results from winter precipitation, and the crop-specific leaching requirements of crops found in the District's service area, it was assumed that no appreciable salt leaching is required in WCWD.

Likewise, agronomic water use for frost protection was assumed to be negligible. Rice is the predominant crop cultivated in WCWD. Freezing temperatures typically occur during the fall and winter decomposition period, outside the growing season, precluding the need for frost protection. Crops that may require frost protection are not cultivated across appreciable acreage in WCWD. Therefore, it was also assumed that no appreciable frost protection is required in WCWD.

Environmental Water Use

In WCWD, environmental water use includes winter deliveries that support wildlife habitat.

As described in Section 7.7.3, the WCWD service area includes approximately 6,500 acres of wetland and riparian habitat, including portions of the CDFW Upper Butte Basin Wildlife Area and the USFWS North Central Valley Wildlife Management Area. WCWD also provides water for habitat to a portion of the Llano Seco Unit of the Sacramento National Wildlife Refuge and to several private duck clubs both inside and outside of its boundary.

The estimated environmental water uses for managed wildlife habitat are summarized in Table 7.15. WCWD records the volume of water released to Butte Creek for use by duck clubs downstream of the District boundaries, based on a 1922 agreement.

Recoverable Flows

The portion of total water supply that is neither consumed by crops nor evaporated from the distribution system is recoverable for other beneficial uses within WCWD, downstream of WCWD, or from the groundwater basins underlying those areas.

Inflows to WCWD are either evaporated from the distribution and drainage system, consumptively used by crops as ET_{aw}, or are recoverable flows to surface water or to groundwater and, as such, available for later use. A significant volume of tailwater, runoff, and other supplies are reused within the WCWD canals to support deliveries. To account for these total recoverable supplies within WCWD, the total deliveries, not consumed as ET_{aw}, plus the total boundary outflows from WCWD are included as recoverable surface flows. Other recoverable flows include seepage from canals to the groundwater system. Table 7.15 summarizes the combined recoverable flows from WCWD.

Water Use Efficiency Fraction

The water use efficiency fraction most applicable to WCWD is the water management fraction (WMF). As depicted in Figure 7.3 and discussed previously, interconnection exists between the accounting centers due to recapture and reuse of water by both WCWD and by individual water users. The District also provides significant volumes of surface water to support environmental uses and other downstream users through deliveries, boundary outflows, and seepage. These outflows are available for beneficial use outside the District's service area. This total water recovery and reuse results in higher levels of aggregate performance than would otherwise occur.

The water management fraction (WMF) can be calculated by comparing the consumptive use of applied water (ET_{aw}) and all recoverable flows in the WCWD service area to the total water supplies available within WCWD. The WMF is calculated on an annual basis at the water supplier scale according to Equation 7.2 (see Section 7.7.5), using the water volumes reported in Table 7.15.

Over the 2015 to 2019 period, the WMF averaged more than 0.99 (99 percent) (Table 7.16). This high WMF indicates that essentially all of WCWD's water supply is used to meet irrigation demands or is recoverable for beneficial use by down gradient surface water and groundwater users. The only water budget flow path that is not recoverable or consumed by crops in WCWD is evaporation from the distribution and drainage system.

Table 7.16. Water Management Fraction.

Year[1]	ET_{aw}[1] (af/year)	Recoverable Flows[2] (af/year)	Inflows[3] (af/year)	Water Management Fraction
2015	147,733	236,634	385,342	0.997
2016	164,970	277,651	443,579	0.998
2017	138,230	343,517	482,673	0.998
2018	136,056	306,689	443,730	0.998
2019	147,653	353,905	502,529	0.998
Average	146,928	303,679	451,571	0.998

[1] In additional to crop consumptive use on farmed lands, a small amount of water is consumptively used by riparian vegetation (approximately 200 af per year).
[2] Total recoverable flows summarized in Table 7.15.
[3] Total inflows to the WCWD distribution and drainage system, summarized in Table 7.13.

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7.8 Climate Change

Climate change has the potential to directly impact surface water resources in the Feather River region and to indirectly impact groundwater resources. Due to the similarity in the nature of diversion agreements with the State among the primary water suppliers relying on the Feather River and due to similarity in cropping, climate, soils, and other factors, potential effects of climate change, impacts on water management, and actions by individual suppliers or through regional coordination to help mitigate future impacts are described for the region as a whole in Volume I, Section 5 of this regional AWMP. In particular, the following are discussed:

- Potential effects of climate change within the region;
- Resulting potential impacts on water resources including water supply, water demand, water quality, and flood control;
- Ongoing and potential future actions to help mitigate future impacts; and
- Additional resources regarding water resources planning to address climate change.

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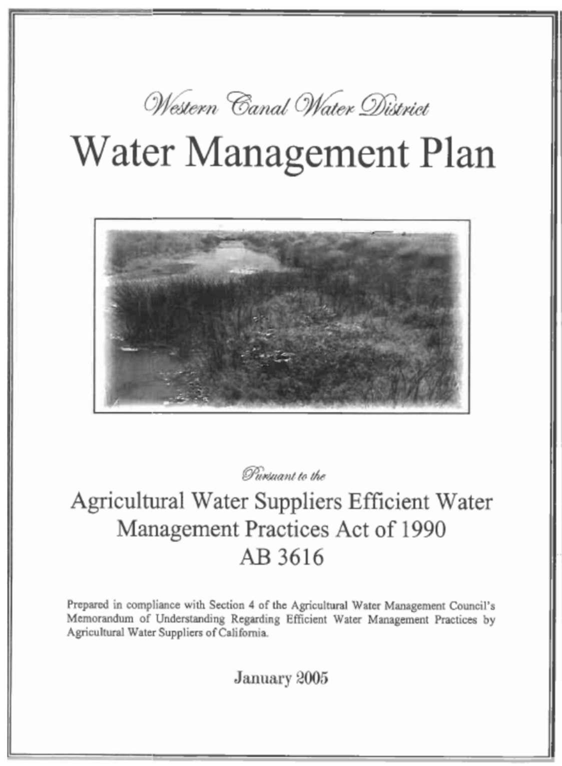
7.9 Efficient Water Management Practices and Water Use Efficiency

7.9.1 Efficient Water Management Practices

WCWD seeks to efficiently manage available water supplies to meet water management objectives, considering operational and financial constraints. WCWD implements technically feasible efficient water management practices (EWMPs) described in the California Water Code (CWC §10608.48) at locally cost-effective levels. Existing and planned water management activities related to each of the EWMPs are summarized in Table 7.17. Water use efficiency improvements achieved through these activities may include increased local, regional, and statewide water supplies and water supply reliability; increased local flexibility; increased in-stream flow; improved water quality; and improved energy efficiency.

Notable water management actions that WCWD has implemented include the following:

- Voluntary preparation and adoption of an AB3616 AWMP in 2005 as a member of the Agricultural Water Management Council (AWMC).
- Longstanding implementation of customer delivery measurement program and volumetric pricing structure, which encourages efficient on-farm water usage;
- Development and implementation of a water information system (WIS) to streamline operational and delivery measurement data collection and management;
- Implementation of FLOW Portal providing growers real-time access to delivery status and water use;
- Provision of flexible deliveries for the range of crops grown and irrigation methods employed;
- Support of on-farm physical and management improvements;
- Automation of control structures along the Western Main Canal, with further automation planned for the future;
- Recovery of drain water into the distribution system for reuse at two locations;
- Promotion of on-farm financing programs and water management services;
- Monitoring operational spillage at key sites in the distribution system multiple times daily;
- Monitoring drain outflows to improve understanding of District's water budget



Western Canal Water District

Water Management Plan

Pursuant to the

Agricultural Water Suppliers Efficient Water Management Practices Act of 1990

AB 3616

Prepared in compliance with Section 4 of the Agricultural Water Management Council's Memorandum of Understanding Regarding Efficient Water Management Practices by Agricultural Water Suppliers of California.

January 2005

WCWD 2005 AWMP.

with planned improvements to provide real-time access to improve operations.

- Evaluation of water management opportunities through a rapid appraisal of opportunities to modernize facilities for water conservation and improved water management performed by the Irrigation Training and Research Center (ITRC) at Cal Poly San Luis Obispo (ITRC 2006);
- Evaluation of opportunities and associated cost to recover and reuse additional drain water through a study performed by MBK Engineers (MBK 2004);
- Evaluation of opportunities to further improve service through automation of control structures, drain water recovery, and flow measurement and telemetry in key locations; and
- Ongoing coordination with DWR operations and other water management entities to evaluate and improve policies to allow for more flexible deliveries and storage.

As part of this plan, reconnaissance level cost estimates have been prepared for potential future water management improvements identified during field inspections and consultations with WCWD staff. Additionally, potential benefits of the improvements have been estimated. These improvements could be implemented over time as determined to be locally cost effective. Alternatively, these projects could be implemented to meet regional and statewide water management objectives. The evaluation of potential water management improvements is included in Section 7.10.4.

Implementation of improvements must consider the nature of water management in the region, whereby water not consumed is available for reuse by downstream water users and the environment. At this time, there is no incentive for the district to implement projects that are not locally cost effective but would result in conserved water remaining in storage. To the extent that such water can be released to increase overall water supplies or to meet timing and water quality objectives, these benefits are realized regionally or statewide by other water users such as State Water Project contractors, providing no direct benefit to the district.

Table 7.17. EWMP Implementation Status.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
Critical (Mandatory) Efficient Water Management Practices				
10608.48.b(1)	Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2).	Being Implemented	• WCWD has implemented a delivery measurement program with approximately 300 propeller meters that satisfies the requirements of CCR 23 §597. • WCWD invested in the development and implementation of a water information system (WIS) to streamline delivery and operational measurement data collection and management. It utilizes field computers to record measurement data and automatically transmit it to a custom database in the district office. The database is used to quality control, process, and store data from the measurement program so that it can be disseminated to district operators and customers in near real time.	• Continue implementation of delivery measurement program, including meter maintenance, testing and calibration, and replacement. • Continue use and enhancement of WIS.
10608.48.b(2)	Adopt a pricing structure for water customers based at least in part on quantity delivered.	Being Implemented	• WCWD's pricing is based directly on the quantity of water delivered; minimum charges apply. • WCWD's WIS will allow for automation of billing processes and support provision of real time information on water use and cost to customers. • Implemented automated billing system to interface with WIS.	• Continue to use pricing structure based on quantity of water delivered. • Continue using automated billing system to interface with WIS.
Additional (Conditional) Efficient Water Management Practices				
10608.48.c(1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Lands with exceptionally high water duties or whose irrigation contributes to significant problems are not found within the district. Furthermore, WCWD's rules and regulations prohibit wasteful use of water, preventing exceptional water duties or significant problems from occurring. Water applied but not consumed to produce crops provides beneficial groundwater recharge or is available for downstream uses.	
10608.48.c(2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils	Not Technically Feasible	There is no available water from municipal or industrial uses within WCWD that meets all health and safety criteria.	
10608.48.c(3)	Facilitate financing of capital improvements for on-farm irrigation systems	Being Implemented	• The district provides at-cost labor and materials to assist landowners in improving on-farm irrigation systems. • WCWD promotes on-farm programs that finance improvements and promote the environment through NRCS, APEP, and others.	• Continue to provide at-cost labor and materials for on-farm improvements, as resources allow. • Continue to promote available on-farm financing and other programs.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
10608.48.c(4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented	• WCWD's pricing structure promotes goal A by charging based on volume delivered, and WCWD promotes goal A by providing growers with real-time access to water delivery status and water use through the FLOW Portal. • The district's water rates promote goals B and C by encouraging the use of available surface water supplies, which provides beneficial groundwater recharge through deep percolation. Groundwater is then available in years of surface water shortage while maintaining long term sustainability of the groundwater system. • WCWD water rates promote goal E by providing a reliable, affordable source of water to maintain both public and private wetlands and aquatic habitat, including winter flooding of rice fields. Among other species, wetlands within the district provide habitat for the Giant Garter Snake, a federally threatened species.	• Continue to promote goals A, B, C, and E through current water rates and other water management activities.
10608.48.c(5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage	Not Locally Cost Effective	• A regulating reservoir would provide limited benefit, as the district is directly adjacent to Thermalito Afterbay and receives relatively steady deliveries from DWR, which limits the benefit a regulating reservoir could provide. Rather, WCWD is increasing flexibility through automation of primary control structures to provide increased flexibility in operating the distribution system. • Soil conditions in the district result in very low seepage rates that would not be substantially reduced through concrete lining and pipeline conversion of existing canals. Any seepage reduction would reduce beneficial groundwater recharge. As a result, lining and pipeline conversion are not locally cost effective.[11]	• None at this time.

[11] Comparison of metered diversions to metered deliveries made possible in 2015 through development and implementation of the WIS supports prior estimates of seepage that are less than 5%.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
10608.48.c(6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits	Being Implemented	• WCWD provides a high degree of flexibility to customers by providing orders typically within the day of the request, always within 24 hours. • The district delivery measurement program results in improved water ordering and delivery to meet customer demands. • WCWD has automated control structures along the Western Main Canal in order to reduce delivery variability. Most recently automated the Nelson Check structure during Winter 2015-2016. • WCWD evaluated opportunities to further improve service through increased automation and implementation of additional flow measurement and SCADA. • As part of the WIS, WCWD provides district operators and customers access to real-time measurement data through an online interface.	• Continue current practices to provide flexibility in ordering and delivery. • Explore options and proceed with automation, flow measurement, and SCADA improvements, contingent on availability of funding and project prioritization. Likely next major projects include the 634 and 1115 check structures. • Continue to provide landowners and growers with access to real-time delivery measurement data through an online interface.
10608.48.c(7)	Construct and operate supplier spill and tailwater recovery systems	Being Implemented	• Drain water recovery by gravity into the distribution system for reuse is currently accomplished in two locations by WCWD. • Evaluated drain water recovery at three additional locations. • Evaluated flow measurement and SCADA capabilities at five key tailwater outflow and drain water recovery sites. • Monitored drain outflow at four key locations: 501 Main Drain, Little Dry Creek, Butte Creek Spill, and Drain 100 during the last five irrigation seasons (2016-2020). • Operational spillage is currently monitored multiple times daily at key locations. • Reporting spill reduction for Nelson Check.	• Continue drain water recovery into the distribution system for reuse. • Explore options and proceed with automation, flow measurement, and SCADA improvements, contingent on availability of funding and project prioritization. • Continue to monitor drain outflows; awaiting decision from the USBR for potential cost-share to setup a District SCADA system and integrate boundary outflow sites.
10608.48.c(8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area	Being Implemented	• An adequate amount of surface water is available for irrigation in most years. During shortage years, groundwater is used conjunctively with reduced surface water supplies to meet demand. • Shortage allocation policies are designed to facilitate the conjunctive use of groundwater in surface water shortage years. • WCWD works in coordination with Butte County, Glenn County, and DWR to monitor and report groundwater levels within its service area. • The district is actively involved in implementation of the Sustainable Groundwater Management Act (SGMA) and works collaboratively with the County, GSAs, and other interested parties to implement the Act.	• Continue usage of surface water when available and conjunctive use of surface water and groundwater during periods of shortage to meet demand. • Continue implementation of SGMA, including active participation in ongoing GSP development and exploring the option of increasing conjunctive use to increase water supply reliability.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
10608.48.c(9)	Automate canal control structures	Being Implemented	• WCWD has automated four control structures along the Western Main Canal. • WCWD has evaluated automation of additional canal control structures.	• Automation for the 634 and 1115 check structures is planned, dependent on funding. • Explore options and proceed with automation of canal control structures, contingent on availability of funding and project prioritization.
10608.48.c(10)	Facilitate or promote customer pump testing and evaluation	Being Implemented	• WCWD promotes available programs regarding pump testing and evaluation through communication with landowners and growers. • The district requires flowmeters on private wells that pump water into the distribution system during shortage years, supporting evaluation of pump performance. • WCWD provides at-cost meter repairs and installation, which facilitates evaluation of pump performance.	• Continue promoting customer pump testing and evaluation through available programs. • Continue to provide at-cost meter repairs and installation.
10608.48.c(11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.	Being Implemented	• WCWD's Special Projects Manager serves as water conservation coordinator and is responsible for implementing AWMP.	• Special Projects Manager will continue to serve as water conservation coordinator.
10608.48.c(12)	Provide for the availability of water management services to water users.	Being Implemented	• WCWD communicates with landowners and growers regarding reports, regulations, drought information, and other water management topics of interest through letters, email, internet, social media, Northern California Water Association (NCWA) and other forms of communication. • The district promotes awareness of water management services such as CIMIS and federal conservation programs (e.g. EQIP). • WCWD provides at-cost labor and materials for on-farm improvements, subject to resource availability. • The district is developing a program to provide periodic electronic updates on water use to landowners and growers during the irrigation season. • As part of WIS development and implementation, WCWD provides customers with access to real-time delivery measurement data through an online interface (FLOW Portal).	• Continue communicating with landowners and growers regarding documents and regulations of interest to landowners and growers. • Continue promoting available water management services. • Continue to provide at-cost labor and materials for on-farm improvements. • Continue to provide landowners and growers with access to real-time delivery measurement data.

Water Code Reference No.	EWMP	Implementation Status	Implemented Activities	Planned Activities
10608.48.c(13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented	• Conducts ongoing interactions with DWR SWP operations (e.g. biweekly meetings during drought seasons and quarterly during non-drought years). • WCWD is a voluntary participant in ACWA, CFWC, NCWA, DWR ASC, and Butte and Glenn County Water Advisory Committees. • WCWD participated in the SVIRWMP and is a voluntary participant in the NSVIRWMP and the FRRAWMP. • WCWD participates in regional water management discussions between Feather River water suppliers and state and federal agencies. • The district is implementing the Sustainable Groundwater Management Act (SGMA) as a party to a Cooperation Agreement and by collaborating with other interested parties.	• Continue interactions with DWR SWP operations. • Continue to evaluate policies of agencies that provide WCWD with water. • Continue to participate in local, regional, and statewide water management groups and initiatives. • Continue to implement SGMA.
10608.48.c(14)	Evaluate and improve the efficiencies of the supplier's pumps.	Not Technically Feasible	WCWD does not own or operate any pumps.	

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7.9.2 Evaluation of Water Use Efficiency Improvements

CWC §10608.48(d) requires that AWMPs include:

> *… a report on which efficient water management practices have been implemented and are planned to be implemented, an estimate of the water use efficiency improvements that have occurred since the last report, and an estimate of the water use efficiency improvements estimated to occur five and 10 years in the future.*

A description of EWMPs that have been implemented by WCWD has been provided previously in Section 7.9.1. This section provides an evaluation of EWMP implementation and an estimate of water use efficiency (WUE) improvements that have occurred in the past and are expected to occur in the future.

The value of evaluating water use efficiency (WUE) improvements (and EWMP implementation in general) from WCWD's perspective is to identify what the benefits of EWMP implementation are and to identify those additional actions that hold the potential to support and advance the district's water management objectives. WCWD's water management objectives include the long term reliability, quality, and affordability of local surface water and groundwater supplies and providing the best service practical to water users it supplies. To that end, WCWD has taken action to develop and maintain reliable surface water and groundwater supplies, to prevent or reduce losses from the distribution system in order to increase operational efficiency, to promote the efficient use of water at the farm level, and to meet changing environmental and other demands that affect the flexibility with which the district can divert and deliver water. WCWD's water management activities are consistent with these objectives and have resulted in local and statewide benefits.

First and foremost among the issues that must be considered in any evaluation of the benefits of EWMP implementation and resulting WUE improvements is how water management actions affect the water balance (Davenport and Hagan, 1982; Keller, et al., 1996; Burt, et al., 2008; Clemmens, et al., 2008; Canessa, et al., 2011). Accordingly, any evaluation of EWMP implementation and WUE improvements for WCWD must consider how water balance changes relate to the district's water management objectives. For example, flows to deep percolation and seepage that could be considered losses in some settings are critical to maintain the long-term sustainability of the underlying groundwater basin. Reductions in these flows resulting from EWMP implementation could be considered WUE improvements at the farm or district scale, but have the consequential effect of diminishing recharge of the underlying groundwater system. Other flows that could be considered losses at the farm or district scale such as spillage and tailwater are also recoverable. For example, spillage from the WCWD distribution and drainage systems is available for beneficial use by downgradient water users. The only distribution and drainage system or on-farm losses that are not recoverable within the WCWD service area, the underlying groundwater basin, or the Feather River region as a whole are canal and drain water surface evaporation and evaporation from irrigation application. These components represent a small portion of WCWD's water supply (less than one percent as indicated in Table 3.13). An implication of this is that very little "new" water can be made available through water conservation in WCWD's service area to increase the

State's overall water supply; however, there may be opportunities to change the timing and amount of water used to meet local, regional, or statewide objectives, as discussed in Volume I, Section 3 of this AWMP.

An important step in evaluating EWMP implementation and water use efficiency improvements is a comprehensive, quantitative, multi-year water balance (see Section 3.7). The quantitative understanding of water use enables identification of targeted flow paths for WUE improvements, along with improved understanding of the beneficial impacts and consequential effects of EWMP implementation at varying spatial and temporal scales. The water balance enables evaluation of potential changes in water use amounts and timing for any given change in water management.

Even where comprehensive, multi-year water balances have been developed, evaluating water balance impacts and WUE improvements is not a trivial task. Issues of spatial and temporal scale and relatively small changes in flow paths resulting from many water management improvements (relative to day to day and year to year variation in water diversions and use) coupled with inaccuracies inherent in even the best water measurement complicate the evaluation of water balance impacts. The implications of recoverable and irrecoverable losses at varying scales complicate the evaluation of WUE improvements, and consequential, potentially unintended effects must be considered.

As part of assembling this AWMP, WCWD has identified the targeted flow paths associated with implementation of each EWMP, the water management benefits of each EWMP and the potential consequential effects of implementation. A brief discussion of the benefits associated with implementation of each EWMP is provided, along with a brief discussion of consequential effects that must be considered. A summary of targeted flow paths, impacts, and consequential effects associated with implementation of each EWMP by WCWD is provided in Table 7.18.

Table 7.18. Summary of Targeted Flow Paths, Impacts, and Consequential Effects Associated with EWMP Implementation.

Water Code Reference No.	EWMP	Implementation Status	Targeted Flow Path(s)	Benefits	Consequential Effects	Notes (See End of Table)
10608.48.b (1)	Measure the volume of water delivered to customers with sufficient accuracy.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Drainage Outflows	Delivery measurement can encourage efficient on-farm water use, and has the potential to lead to reduced deliveries, dependent on pricing. Reduced deliveries result in reduced diversions, which result in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation.	1
10608.48.b (2)	Adopt a pricing structure based at least in part on quantity delivered.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Drainage Outflows	Volumetric pricing may result in increased efficiency of on-farm water use, which has the potential to lead to reduced deliveries. Reduced deliveries result in reduced diversions, which result in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation.	1
10608.48.c (1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Not Applicable	Not Applicable	Not Applicable	2
10608.48.c (2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	Not Technically Feasible	Not Applicable	Not Applicable	Not Applicable	2
10608.48.c (3)	Facilitate financing of capital improvements for on-farm irrigation systems.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Groundwater Pumping, Drainage Outflows	Assisting in on-farm improvements through the provision of at-cost labor and materials can result in reduced deliveries due to increased delivery efficiency and/or reduced tailwater and, in some cases, deep percolation. Reduced deliveries result in reduced diversions, which result in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1

Water Code Reference No.	EWMP	Implementation Status	Targeted Flow Path(s)	Benefits	Consequential Effects	Notes (See End of Table)
10608.48.c (4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented	Varies	Volumetric pricing promotes goal (A), resulting in on-farm benefits as described for the volumetric pricing EWMP (10608.48.b(2)). Provision of surface water at lower rates than the cost of groundwater pumping incentivizes goals (B) and (C) and improves the reliability of regional water supplies while maintaining and enhancing ecosystems. Provision of water at affordable rates incentivizes goal (E) by offering a reasonably priced, reliable source of water to maintain both public and private waterfowl habitat and wetlands, including winter flooding of rice fields.	Consequential effects of volumetric pricing are the same as described for the volumetric pricing EWMP (10608.48.b(2)).	1
10608.48.c (5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.	Not Locally Cost Effective	Deliveries, Spillage, Tailwater, Deep Percolation, Seepage, Diversions, Drainage Outflows	Benefits of lining, pipeline, and regulating reservoirs are reductions in losses such as seepage, operational spillage, and drainage outflows. In addition, regulating reservoirs provide improved consistency in deliveries, potentially providing a modest reduction in on-farm deliveries due to reduced tailwater and, in some cases, deep percolation and tailwater. Due to the proximity of the district's system to Thermalito Afterbay and heavy soils, which limit seepage losses, these benefits do not outweigh the costs at this time. Water quality benefits may occur through reduced tailwater outflow.	Reduced seepage and deep percolation result in reduced beneficial recharge of the underlying groundwater system. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	Being Implemented	Deliveries, Spillage, Tailwater, Deep Percolation, Diversions, Drainage Outflows	Flexible water ordering and deliveries result in reduced operational spillage, tailwater, and, in some cases, seepage and deep percolation. It can also result in a modest reduction in deliveries due to on-farm reductions in tailwater and deep percolation. System improvements result in greater operational efficiency and reductions in spillage. Additionally, water quality benefits may occur through reduced tailwater outflow. In aggregate, reduced losses (both on-farm and at the district level) can lead to reduced deliveries and reduced diversions. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (7)	Construct and operate supplier spill and tailwater recovery systems.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Drainage Outflows	Reuse of operational spillage and tailwater results in decreased required diversions. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment. Tailwater may be of diminished quality as compared to other available water supplies. Spillage and tailwater recovery using pumps requires the use of electricity or fuel as a component, increasing energy demand.	1

Water Code Reference No.	EWMP	Implementation Status	Targeted Flow Path(s)	Benefits	Consequential Effects	Notes (See End of Table)
10608.48.c (8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area.	Being Implemented	Diversions, Deliveries, Deep Percolation, Groundwater Pumping	Conjunctive management provides multiple benefits: • Maintain local and statewide water supply reliability • Enhance aquatic and wetlands ecosystems • Reduce energy requirements for irrigation	Not Significant	1
10608.48.c (9)	Automate canal control structures.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Drainage Outflows	Automation results in reduced operational spillage and reduced deliveries due to increased delivery efficiency, which reduces on-farm tailwater and, in some cases, deep percolation. Reduced deliveries result in reduced diversions, which results in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (10)	Facilitate or promote customer pump testing and evaluation.	Being Implemented	None	Improved pumping efficiency by WCWD's customers results in decreased energy demand and reduced pumping costs for customers. There are no direct benefits to WCWD.	Not Significant	
10608.48.c (11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	Being Implemented	Varies	See Comment	See Comment	3
10608.48.c (12)	Provide for the availability of water management services to water users.	Being Implemented	Deliveries, Spillage, Tailwater, Diversions, Groundwater Pumping, Drainage Outflows	Promoting available water management services can increase efficiency of on-farm water use, which has the potential of leading to reduced deliveries. Reduced deliveries result in reduced diversions, which result in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and can improve local supply reliability or could potentially be available for transfer. Additionally, water quality benefits may occur through reduced tailwater outflow.	Increased on-farm water use efficiency results in reduced tailwater available for reuse by downstream water users. For crops other than rice, increased on-farm efficiency results in reduced beneficial recharge to the groundwater system through deep percolation. Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented	Diversions	Increased flexibility and storage for the surface water supply could result in reductions in losses to operational spillage, tailwater, and drainage outflows. Additionally, water quality benefits may occur through reduced tailwater outflow.	Reduced operational spillage, tailwater, and drainage outflows result in reduced water available downstream for beneficial use for agriculture or the environment.	1
10608.48.c (14)	Evaluate and improve the efficiencies of the supplier's pumps.	Not Technically Feasible	Not Applicable	Not Applicable	Not Applicable	4

Notes:

1. WCWD works to balance tradeoffs between incentivizing water conservation (both districtwide and on-farm) and maintaining long-term surface water and groundwater reliability.
2. Such conditions do not exist in WCWD. As a result, it is not technically feasible to implement this EWMP.
3. Implementation of the AWMP by WCWD's water conservation coordinator and other staff as appropriate is the mechanism by which all EWMPs are implemented and targeted benefits are realized.
4. WCWD does not own or operate any pumps.

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WUE definitions vary. For purposes of evaluating WUE improvements associated with EWMP implementation by WCWD, specific WUE improvement categories or objectives have been identified that correspond to each EWMP. Potential WUE improvements include reduction of irrecoverable losses, increased local supply and supply reliability, increased local flexibility, increased in-stream flow, improved water quality, and improved energy efficiency. Definitions for each of the WUE improvement categories have been developed and are provided in Table 7.19. Note that the WUE improvement categories are not mutually exclusive in many cases. For example, reductions in irrecoverable losses could be used to increase local supply. The applicability of each EWMP to each WUE improvement category based on WCWD's water management activities has been identified and is presented in Table 7.20.

Table 7.19. WUE Improvement Categories.

Water Use Efficiency Improvement Category	Definition
Reduce Irrecoverable Losses	Reduce losses that cannot be recovered and used by the water supplier or downgradient users (e.g. evaporation and flows to salt sinks).
Increase Local Supply (and Supply Reliability)	Reduce losses and/or increase storage locally to increase supply available to meet demands, including both near-term (within an irrigation season) and long-term (over more than one year).
Increase Local Flexibility	Improve the supplier's ability to divert, pump, convey, control, and deliver available water supplies to meet customer demands.
Increase In-Stream Flow	Increase flow in natural waterways to benefit fisheries or meet other environmental objectives.
Improve Water Quality	Increase the quality of targeted water bodies (i.e. streams, lakes, or aquifers).
Improve Energy Efficiency	Increase the efficiency of water supplier or customer pumps.

In order to more explicitly report an estimate of WUE improvements and an estimate of WUE improvements expected to occur five and ten years in the future, WCWD has estimated the qualitative magnitude (expressed as None, Limited, Modest, or Substantial in order of increasing relative magnitude) for the targeted flow paths associated with each EWMP relative to the applicable WUE improvement categories identified in Table 7.19. Past WUE improvements are estimated relative to no historical implementation. WUE improvements relative to the time of the last plan are estimated in reference to 2015, the time of adoption of the district's prior AWMP. Future WUE improvements are estimated for five years in the future (2025) relative to 2020 and for ten years in the future (2030) relative to 2020. The result of this evaluation is provided in Table 7.21.

WCWD will continue to seek out and implement water management actions that meet its overall water management objectives and result in WUE improvements. The continuing review of water management within WCWD, coupled with exploration of innovative opportunities to improve water management will result in future management improvements by the district and resulting WUE improvements.

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Table 7.20. Applicability of EWMPs to WUE Improvement Categories.

Water Code Reference No.	EWMP	Implementa-tion Status	Potential Water Use Efficiency Improvement Category					
			Reduce Irrecover-able Losses	Increase Local Supply	Increase Local Flexibility	Increase In-Stream Flow	Improv e Water Quality	Improve Energy Efficiency [1]
10608.48.b (1)	Measure the volume of water delivered to customers with sufficient accuracy.	Being Implemented		□		□	□	□
10608.48.b (2)	Adopt a pricing structure based at least in part on quantity delivered.	Being Implemented		□		□	□	
10608.48.c (1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Not Applicable to WCWD					
10608.48.c (2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	Not Technically Feasible	Not Applicable to WCWD					
10608.48.c (3)	Facilitate financing of capital improvements for on-farm irrigation systems.	Being Implemented		□		□	□	
10608.48.c (4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented		□		□	□	
10608.48.c (5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.	Not Locally Cost Effective		□	□	□	□	
10608.48.c (6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	Being Implemented		□	□	□	□	
10608.48.c (7)	Construct and operate supplier spill and tailwater recovery systems.	Being Implemented		□	□	□	□	
10608.48.c (8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area.	Being Implemented		□				
10608.48.c (9)	Automate canal control structures.	Being Implemented		□	□	□	□	
10608.48.c (10)	Facilitate or promote customer pump testing and evaluation.	Being Implemented						□
10608.48.c (11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	Being Implemented	The activities of the Water Conservation Coordinator and other WCWD staff to achieve WUE improvements through implementation of the AWMP are described individually by EWMP.					
10608.48.c (12)	Provide for the availability of water management services to water users.	Being Implemented		□		□	□	□
10608.48.c (13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented		□	□	□	□	
10608.48.c (14)	Evaluate and improve the efficiencies of the supplier's pumps.	Not Technically Feasible	Not Applicable to WCWD					

1. Includes reducing energy demands.

Table 7.21. Relative Magnitude of Past and Future WUE Improvements by EWMP.

Water Code Reference No.	EWMP	Implementation Status	Marginal WUE Improvement[1,2]			
			Past		Future	
			Relative to No Historical Implementation[3]	Since Last AWMP[4]	5 Years in Future[5]	10 Years in Future[5]
10608.48.b (1)	Measure the volume of water delivered to customers with sufficient accuracy.	Being Implemented	Modest	None	None	
10608.48.b (2)	Adopt a pricing structure based at least in part on quantity delivered.	Being Implemented	Modest	None	None	
10608.48.c (1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Not Technically Feasible	Not Applicable to WCWD			
10608.48.c (2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	Not Technically Feasible	Not Applicable to WCWD			
10608.48.c (3)	Facilitate financing of capital improvements for on-farm irrigation systems.	Being Implemented	Modest	Limited	Limited	
10608.48.c (4)	Implement an incentive pricing structure that promotes one or more of the following goals: (A) More efficient water use at farm level, (B) Conjunctive use of groundwater, (C) Appropriate increase of groundwater recharge, (D) Reduction in problem drainage, (E) Improved management of environmental resources, (F) Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Being Implemented	Modest (Goals A, B, C & E)	None	None	
10608.48.c (5)	Expand line or pipe distribution systems, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.	Not Locally Cost Effective	None (Flexibility Improvements Achieved through Canal Automation)			
10608.48.c (6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	Being Implemented	Substantial	Modest	Modest	Modest, Depending on Funding
10608.48.c (7)	Construct and operate supplier spill and tailwater recovery systems.	Being Implemented	Modest	None	Modest, Depending on Funding	
10608.48.c (8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area.	Being Implemented	Substantial	Modest	Modest, Depending on Opportunities	
10608.48.c (9)	Automate canal control structures.	Being Implemented	Substantial	None	Modest	Modest, Depending on Funding
10608.48.c (10)	Facilitate or promote customer pump testing and evaluation.	Being Implemented	Limited	Limited	None	
10608.48.c (11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress report.	Being Implemented	The activities of the Water Conservation Coordinator and other WCWD staff to achieve WUE improvements through implementation of the EWMPs are described individually by EWMP.			
10608.48.c (12)	Provide for the availability of water management services to water users.	Being Implemented	Modest	Modest	None	
10608.48.c (13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Being Implemented	Substantial	Modest	Modest, Depending on Outcomes	
10608.48.c (14)	Evaluate and improve the efficiencies of the supplier's pumps.	Not Technically Feasible	Not Applicable to WCWD			

1. As noted herein and throughout this analysis, reductions in losses that result in WUE improvements at the farm or district scale do not result in WUE improvements at regional scale, except in the case of evaporation reduction. All losses to seepage, spillage, tailwater, and deep percolation are recoverable within the WCWD service area or by downgradient water users.
2. Quantitative estimates of improvements are not available. Rather, qualitative estimates are provided as follows, in increasing relative magnitude: None, Limited, Modest, and Substantial.
3. WUE Improvements occurring in recent years relative to if they were not being implemented.
4. WUE Improvements occurring in recent years relative to the level of implementation at time of WCWD 2005 AWMP.
5. WUE Improvements expected in 2025 (five years in the future) and 2030 (ten years in the future), relative to level of implementation in recent years.

7.10 Attachments

This section includes the following attachments:

- 7.10.1 – Public Coordination and Adoption
- 7.10.2 – Bylaws
- 7.10.3 – Agricultural Water Measurement Compliance Documentation
- 7.10.4 – Potential Projects to Enhance Water Management Capabilities
- 7.10.5 – Drought Management Plan

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Chico Enterprise-Record
400 E. Park Ave.
Chico, Ca 95928
530-896-7702
erlegal@chicoer.com

2124135

WESTERN CANAL WATER DISTRICT
2003 NELSON ROAD
NELSON, CA 95958

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA, IN AND FOR THE COUNTY OF BUTTE

In The Matter Of
Public Notice - Adoption of Agricultural Water Management Plan

AFFIDAVIT OF PUBLICATION

STATE OF CALIFORNIA }
COUNTY OF BUTTE } SS.

The undersigned resident of the county of Butte, State of California, says:

That I am, and at all times herein mentioned was a citizen of the United States and not a party to nor interested in the above entitled matter; that I am the principal clerk of the printer and publisher of

The Chico Enterprise-Record
The Oroville Mercury-Register

That said newspaper is one of general circulation as defined by Section 6000 Government Code of the State of California, Case No. 26796 by the Superior Court of the State of California, in and for the County of Butte; that said newspaper at all times herein mentioned was printed and published daily in the City of Chico and County of Butte; that the notice of which the annexed is a true printed copy, was published in said newspaper on the following days:

04/06/2021, 04/13/2021

Dated April 28, 2021
at Chico, California

(Signature)

Legal No. **0006561800**

PROOF OF PUBLICATION

NOTICE OF CONSIDERATION OF ADOPTION OF AGRICULTURAL WATER MANAGEMENT PLAN.

Notice is hereby given that Western Canal Water District shall hold a public hearing to consider the adoption of the District's 2020 update to the applicable sections of the 2015 Feather River Regional Agricultural Water Management Plan (AWMP). The hearing shall be held on April 20, 2021 commencing at 10:00 am at 2003 Nelson Road, Nelson, CA. The AWMP proposed for adoption is publicly available at the District office located at 2003 Nelson Rd., Nelson, CA 95958 and available at http://westerncanal.com/feather-river-awmp-info. Please submit questions or comments concerning the proposed AWMP in writing to the District at P.O. Box 190, Richvale, CA 95974 prior to the hearing date.
4/06, 4/13/2021

r.BP7-01/27/16 1

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Western Canal Water District <info@westerncanal.com>

PUBLIC NOTICE: Draft Feather River Regional and Western Canal Water District Ag Water Management Plan

1 message

Western Canal Water District <info@westerncanal.com> Wed, Mar 17, 2021 at 3:13 PM
To: Anjanette Shadley <anjanette@westerncanal.com>
Bcc: BCWater <BCWater@buttecounty.net>, Valley Mirror <valleymirror@pulsarco.com>, Bridget Gibbons <bridget.gibbons@wildlife.ca.gov>, Lisa Hunter <LHunter@countyofglenn.net>, barbarav@aqualliance.net, mfahey@countyofcolusa.org, jimb@aqualliance.net, Todd Turley <tturley@ari-slc.com>, Susan Strachan <susanpstrachan@gmail.com>, tito.cervantes@water.ca.gov, Ted Trimble <ted@westerncanal.com>

Dear Interested Parties:

Please see notice of the Draft 2020 FRRAWMP and WCWD AWMP updates available on our website.

Please contact Anjanette Shadley, Assistant General Manager at the numbers below.

--

Western Canal Water District

P.O. Box 190 | Richvale, CA 95974-0190

P 530.342.5083 | F 530.342.8233

WESTERNCANAL.COM

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April 15, 2021

AGENDA

April 20, 2021
9:00 AM DISTRICT OFFICE

OPTIONAL CONFERENCE CALL LINE
(530) 207-0908

WESTERN CANAL WATER DISTRICT
BOARD OF DIRECTORS MEETING

1. CALL TO ORDER

2. PUBLIC COMMENTS……………………………………

3. Approval of the Minutes of the Regular Meeting 3/16/21
4. Financial Reports
5. Payment of the Bills
6. Manager Report
7. Attorney Report

- BUSINESS………………………………………………..

8. **Public Hearing**: Receive Public Comment on Adoption of the Feather River Regional Agricultural Water Management Plan 2020 Update (10:00 AM)
9. Consideration of Resolution 2021-03 to Adopt the Feather River Regional Agricultural Water Management Plan 2020 Update
10. Consideration of Butte Local Agency Formation Commission Director Election Ballots
11. Consideration of Request for Contribution/Membership for the Water Education Foundation
12. Adoption of WCWD 2021 Final Water Supply Allocation
13. Discussion of Sustainable Groundwater Management Act (SGMA) Activities
14. CLOSED SESSION PER GOVERNMENT CODE 54956.9 - Conference with Legal Counsel – EXISTING LITIGATION (Paragraph (1) of subdivision (d): Bay-Delta proceedings, including the California WaterFix, the associated environmental document and change petition pending before the State Water Resources Control Board and the planned update to the Bay-Delta Water Quality Control Plan.

- REPORTS…………………………………………………
15. President Johnson
16. Director Larrabee
17. Director Lundberg
18. Director Sheppard
19. Director Davis

20. Adjournment………………………………………………

P.O. BOX 190, RICHVALE, CA 95974 | (P) 530.342.5083 | (F) 530.342.8233 | INFO@WESTERNCANAL.COM

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April 15, 2021

AGENDA

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OPTIONAL CONFERENCE CALL LINE
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- REPORTS……………………………………………………
15. President Johnson
16. Director Larrabee
17. Director Lundberg
18. Director Sheppard
19. Director Davis

20. Adjournment………………………………………………

P.O. BOX 190, RICHVALE, CA 95974 | (P) 530.342.5083 | (F) 530.342.8233 | INFO@WESTERNCANAL.COM

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RESOLUTION 2021-03

Resolution of the Board of Directors of Western Canal Water District to Adopt the Feather River Regional Agricultural Water Management Plan - 2020 Update

WHEREAS, the Board of Directors of Western Canal Water District ("Board") has caused the preparation of an Agricultural Water Management Plan 2020 Update pursuant to the Water Conservation Act of 2009, SBX7-7; and

WHEREAS, the Western Canal Water District Feather River Regional Agricultural Water Management Plan 2020 Update ("Plan") has been prepared and updated in compliance with Part 2.8 of Division 6 of the California Water Code; and

WHEREAS, in compliance with the requirements set forth in Section 10841 of the Water Code, the Board made the Plan available for public inspection, caused notice of the time and place of this hearing considering adoption of the Plan to be published in accordance with applicable statutory requirements, and such notice was published on or about April 6th, 2021 and on or about April 13th, 2021 in the Enterprise-Record; and

WHEREAS, pursuant to Section 10851 of the Water Code, the California Environmental Quality Act ("CEQA") does not apply to the preparation and adoption of the Plan.

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of Western Canal Water District that the Feather River Regional Agricultural Water Management Plan 2020 Update is hereby approved and adopted.

BE IT FURTHER RESOLVED that the Board is authorized to implement the adopted Plan in accordance with any schedules set forth therein, and to take all steps necessary to publish and submit the Plan in compliance with Part 2.8 of Division 6 of the California Water Code.

PASSED AND ADOPTED this 20th day of April, 2021 at Nelson, California, the following Directors voting thereon:

Ayes: Johnson, Larrabee, Lundberg, Sheppard, Davis
Noes: 0
Abstain: 0
Absent: 0

BY ______________________
Greg Johnson, President of the Board

ATTEST: ______________________
Ted Trimble, Secretary to the Board

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7.10.2 Bylaws

WCWD’s bylaws are provided on the following pages.

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FIRST AMENDED BYLAWS

WESTERN CANAL WATER DISTRICT

PREAMBLE:

Western Canal Water District is a political subdivision of the State of California formed and existing pursuant to the provisions of Division 13 of the Water Code of the State of California. The District was formed on December 21, 1984, includes comprises approximately 59,000 irrigable acres in Butte and Glenn Counties. The District derives its water supply from direct diversion appropriative rights in the Feather River with a priority date of 1908, and from delivery by PG&E, through the facilities of the State Water Project, at the Thermalito Afterbay, and by direct diversion from Butte Creek.

A five member Board of Directors elected for staggered four year terms, governs the District. The general District election is held in November of odd-numbered years.

I. Definitions:

As used herein, the following words have the following meanings:

"District" means the Western Canal Water District.

"Application" means the annual application for irrigation service from the District and/or the annual application for winter water or waterfowl habitat service from the District during the non-irrigation season.

"Board" means the Board of Directors of Western Canal Water District.

"Irrigation Season" will be the period from April 1 to November 1.

"General Manager" means the General Manager of the District who is appointed by the Board of Directors.

"Works" of the District include all canals, laterals, ditches, drains, pipelines, conduits, crossings, pumps, check gates, weirs, and measuring devices used in connection with such facilities, and all other facilities owned and operated by the District and used in connection with the performance of its business of distributing water within the District.

"Private Conduits" means ditches, pipelines, standpipes, drains, pumps, and structures within the District owned by private persons.

"Person" means any person, firm, association, organization, partnership, business trust, corporation or company. Person does not include a public agency of the state or a special district.

"Customer" means any landowner or water user ordering and receiving water service from the District.

II. General Information:

1. Western Canal Water District is a landowner-voting District. A voter is a "person" owning land in the District and such persons owning land are eligible to vote at District elections and all lands within the District are eligible to vote at District elections either through the landowner, by proxy, or in the case of landowners composed of corporations or other similar legal entities, through a legal representative. Forms of proxies and of legal representation are available from the District Office.

2. Directors of Western Canal Water District must be persons who are owners of land within the District, or legal representatives thereof. Other officers of the District need not be landowners.

3. Directors of Western Canal Water District will be compensated in accordance with the provision of Section 20200, et seq. of Division 10 of the Water Code of the State of California. Attendance at meetings of the Board, or attendance at meetings on behalf of the Board as directed by the Board of Directors shall be considered as a day of service on behalf of the District. Other service rendered as a member of the Board of Directors at the request of the Board will be compensated in accordance with the determination of the Board as to the reasonable time required for such services to the District.

4. The address of the District Office is 2003 Nelson Rd., Nelson, California. The District may change the location of its office upon resolution of its Board of Directors.

5. The District is governed by the provisions of Division 13 of the Water Code, Rules and Regulations of the District, and Bylaws of Western Canal Water District. The Bylaws are adopted by the Board of Directors subsequent to approval by the Board of Supervisors of the County of Butte, State of California. Amendments to the Bylaws may be made by Resolution of the Board of Directors and are subject to the approval of the Board of Supervisors of the County of Butte. The alternate procedure for amendment of Bylaws is through a direct vote of the landowners.

6. The regular meeting of the Board of Directors shall be held on the third Tuesday of each month, at the hour of 9:00 a.m. at District headquarters. The Board of Directors reserves the right to modify the date and time of the regular meeting as necessary to meet the schedule and availability of Board members and to, by resolution, establish a different time and place for the regular District Board of Directors' meeting. Adjourned meetings and special meetings may be

scheduled as required and in accordance with law.

III. Control of the System:

1. The distribution system and works of the District are under the exclusive management and control of the General Manager, who is appointed by the Board of Directors. No other person shall have any right to interfere with said distribution system and works of the District in any manner whatsoever.

2. The General Manager shall appoint and employ such assistants and other employees as he may deem necessary for the proper operation of the system, subject to the approval of the Board, and at rates of compensation that will be fixed by the Board. The General Manager may delegate his authority with respect to the operations of the works of the system to other employees of the District, at his discretion.

IV. Ownership of Water.

1. All water delivered by the District is the property of the District and is subject to diversion, rediversion, reclamation, reuse, sale and resale, by the District as it sees fit. Landowner shall have a right to service from the District but no landowner or water user acquires any proprietary right to the water delivered to him by the District by reason of such use, nor does such landowner or consumer acquire any right to resell the water purchased or used, or the right to use it on premises or for a purpose other than for which it was applied and as stated in the Application. The District expressly asserts the right to recapture, reuse, and resell all water that passes from the premises described in the application as the place of use, and asserts its rights to all waters within the District.

2. If a person uses water on lands outside of the District that was applied for use within the District, whether by routing through a conduit, first flowing it across land within the District, by recapturing it from drains, or otherwise, the District may refuse service to the land within the District for which the Application was made until all charges for use of the water on the outside land, as fixed by the Board, are paid and the person makes such physical changes in his fields or irrigation systems as the Board deems necessary to assure the District that no future use of District water on the outside land can occur.

3. All persons intercepting, using, or impounding District water will be charged for such water at the rates established by the District, irrespective of whether the water is diverted or pumped from a conduit, taken from or impounded in a natural channel or drain, or whether it is waste, spill, seepage, runoff or other water. In order for water rates to be kept as low as possible, water users should notify the General Manager or canal operator of any waste or unauthorized use of water.

V. Applications for Water Use:

1. Applications for water use for the irrigation season must be filed with the District prior to April 1 of each year or at such later date as may be established by the Board, on forms furnished by the District. In the event of a shortage of water supply, if an application for agricultural water use shall not be received prior to April 1, that land may not be entitled to receive water during the water year without the express permission of the Board. Application for special service or water service during the non-irrigation season shall be required on forms and at times as specified annually by the Board of Directors.

2. In submitting an application for water, customers agree to be bound by the rules and regulations, and the bylaws, of the District, as they may exist, or as they may be modified from time to time. Customers also agree, in submitting said application, that the District, and its employees, will have access to and across the lands of customer for purposes of managing and regulating water and for inspecting the facilities for the distribution of water provided by the District.

3. In the event of a shortage of water, the Board shall establish rules for the proration of water, as necessary, prior to the irrigation season.

VI. Charges for Water Service:

1. The District shall, on or before April 1 of each year, establish appropriate charges for the delivery of water from the District. The charges that may be levied by the District include, but are not limited to, a standby charge and a water charge. Customers shall pay the standby charge for all irrigable acres within the District whether or not water is actually received, or ordered for those lands. The Board of Directors shall determine the irrigable acres based on relevant data, including Farm Service Administration acreage determinations or other appropriate criteria. All customers who are receiving irrigation water shall pay the water charge. The District reserves the right to establish additional rates and charges for purposes of meeting the costs and expenses of operating the District.

2. No water shall be delivered to any land if there is any outstanding or delinquent charge due and owing to the District for services provided by the District, including winter water service. The District has established penalties and delinquency fees to be paid in the event any water or standby charge is not paid when due and becomes delinquent. As an accommodation, the District may provide service to tenants, but the responsibility to pay for services provided to any tenant remains with the landowner.

3. Failure to receive a bill for water service shall not in any way excuse a landowner, or recipient of water, from the obligation to pay the applicable rates and charges for the water delivered.

4. Applicable water charges, including standby charges, shall be due and payable as determined by the Board of Directors. The Board shall establish times at which all applicable rates and charges, including standby charges, shall become delinquent and shall impose penalties, including interest and other penalties, if not paid by the date established by the Board of Directors.

VII. Liability for Delinquent Bills:

Landowners are responsible for the payment of all water charges applicable to their lands. Any delinquent water charges, or standby charges, will be subject to penalties and interest as established by the Board, and will be made a lien upon the land. It shall be the responsibility of the landowner to secure payment of said charges, whether by the tenant or by the landowner directly. In accepting an application for water service from a tenant, the District shall in no way waive its rights to collect all applicable water charges and standby charges from the landowner and to place any delinquent charges as a lien against the landholdings.

VIII. Control of Water:

No person within the District, other than the General Manager, or a delegated representative, shall operate the works of the District nor take any action to modify, control, interrupt, or effect the delivery of water by the District to any lands within the District without the consent of the District's General Manager.

IX. Shortages of Water:

The District shall not be liable for any damage that may result from an interruption or lack of service due to a shortage of water, or to any other cause that is beyond the control of the District. Temporary shutdowns may be made by the District to make improvements and repairs as necessary. Whenever possible and if time permits, landowners effected by such a shutdown shall be notified prior to the shutdown taking place.

X. Credit Deposits:

Prior to providing water service to any landowner or tenant who has, within the three years immediately prior to said application, been delinquent in the payment of any District water charge or standby charge the District may, in the discretion of the Board of Directors, require a deposit for all or a portion of the water charges anticipated to be levied for the coming water year. A deposit may also be required from a tenant if requested by the landowner. Landowners who have availed themselves of the protection of the bankruptcy laws may be required to pay for future service in advance.

XI. Condition of Private Laterals and Conduits:

All private conduits must be in a condition to receive and transport water without waste and must be kept free from debris and other obstructions which, in the opinion of the General Manager, restrict the capacity of the canal or conduit below that which is necessary for the provision of water service. Customers shall, as soon as receiving notification thereof from the District's General Manager, make such improvements or modifications as are necessary to properly clean and maintain private conduits, or to restore private conduits to a condition where reliable water service can be provided. Failure to comply with an order of the General Manager to maintain or improve the private conduit shall relieve the District of any and all responsibility or liability for not delivering water and the District may, thereafter, refuse to deliver water to said facility.

XII. Quality of Water:

The District transports and delivers raw water for agricultural purposes only, and the water is not fit for human consumption and is not marketed for any domestic use whatsoever. The purpose of District water supply is for the irrigation of crops, straw-decomposition, and waterfowl habitat, and no landowner shall make an additional use of District's water supply without the express consent of the Board of Directors of the District. Customers shall assume full responsibility for and hold the District harmless from all damages resulting from an unauthorized use of District water.

XIII. District Employees:

District vehicles, tools, equipment, or manpower may not be used for the provision of any service to any landowner or water user within or without the District without the express authorization of the Board.

XIV. Recreational Use of Works of the District:

The canals, conduits, and other works of the District are maintained and dedicated to the provision of agricultural irrigation water to the lands within the District. The use of these facilities for recreational purposes, play, or other similar purposes is expressly prohibited.

Customers are urged to prevent use of District works and their banks for swimming or play. Water in many of the conduits is cold, swift and deep, and the conduits cover so many miles of the District that supervision of their use for recreation is impossible.

Any person who shall permit any equipment, livestock, poultry or waterfowl to damage or injure any works of the District, or who shall damage, injure or destroy by burning or otherwise any such works, or who shall dump any rubbish or pollutants therein or thereon, or who will erect signs, fences or structures on the District rights of way, will pay to the District upon demand all expenses incurred in repairing the damage or removing the rubbish, pollutants, signs, fences, or structures, including the reasonable value of staff time and attorney fees expended in enforcing this provision.

XV. Canal Bank Roads:

Use of District canal bank roads is at the sole risk of the user. The use of such roads by vehicles not owned by the District is prohibited where District signs, chains, or other barricades so indicate. Public use of canal bank roads without written permission of the General Manager may also be prohibited during certain periods of the year.

XVI. Water Use:

The District is primarily in existence for the purpose of supplying water to lands for irrigation, straw-decomposition, waterfowl, and other agricultural uses. The District, incidentally, provides water, in a non-irrigation season, for the flooding of duck clubs in the Butte Sink area.

When authorized by the Board of Directors, the District will consider the provision of water, for flooding of duck ponds within the boundaries of the District, but only when such service will not, in the opinion of the General Manager, through seepage or overflow from conduits or the fields flooded, interfere with the agricultural operations of other landowners, or interfere with the District's ability to operate and maintain its canal system.

XVII. Waste of Water:

Any customer, who in the opinion of the General Manager, is wasting water (on roads or vacant land, or land previously irrigated) either willfully, carelessly, negligently, or on account of defective private conduits, or who shall collect any portions of its land to an unreasonable depth, or use an unreasonable amount of water in order to properly irrigate other portions, or whose land has been improperly prepared for the economical use of water, or who allows an unnecessary amount of water to escape from any tail gate, may be refused the use of water until such conditions are remedied, or the District may reduce the inflow into the customer's fields to a flow that would be reasonable if such conditions were remedied.

The District reserves the right to refuse delivery of water when, in the opinion of the General Manager, the proposed use, or method of use, will require such extensive quantities of water as to constitute waste.

XVIII. Nonliability of District:

The District will not be liable for any damage of any kind or nature resulting directly or indirectly from the use of a private conduit or by reason of lack of capacity in any private or District conduit or for negligent, wasteful, careless or other use or handling of water by customers.

The District does not guaranty an uninterrupted supply of water nor is the District responsible for interruption or shortage of distribution capacity or water supply for any reason, including but not limited to excessive demand, drought, canal breaks or scheduled or unscheduled maintenance.

The water supply of the District flows through many miles of river channels and open canals and the District assumes no responsibility for the quality of the water, temperature, or fluctuations in flow.

Customers pumping water do so at their own risk and the District is not responsible for damages to pumping equipment used to lift or reclaim District-supplied water.

XIX. Freedom from Obstruction:

No fences, bridges, ditches, buildings or other obstructions shall be placed by any customer across or upon, or along any canal, ditch, right of way, or property of the District without first obtaining the written permission of the District's General Manager.

XX. Transfers of District Water.

The Board of Directors reserves the right to enter into negotiations and to negotiate appropriate terms and conditions related to the transfer of a portion of the District's water supply. Transfers may be implemented through the reduction in diversions of the District's deliveries from State Water Project facilities; substitution of groundwater for surface water; reduction in diversion as a result of land idling; or reduction and sale of contract quantities as determined reasonable and necessary by the Board of Directors. No individual landowner within the District shall have the right to negotiate for and/or to carry out a transfer of a portion of the water supply available to said landowner unless prior approval is received from the Board of Directors.

XXI. Ownership of Structures:

All structures and meters used for the provision, measurement, or regulation of water service from District works shall be constructed and installed by the District or under its direction and supervision, and in compliance with all applicable District specifications.

XXII. Annexation and Detachment.

The Board of Directors of Western Canal Water District shall have the right, in accordance with the provisions of Division 3 of Title 5 of the Government Code, to undertake proceeding for annexation into and detachment from the boundaries of the District and to establish and modify the Sphere of Influence of the District. The Board of Directors shall require an agreement with landowners prior to seeking annexation. Annexation shall be either "primary," according to the annexee full rights, including a pro rata share of District's water supply, or secondary, according to the annexee as-available water when determined to be surplus to the needs of the primary landowners of the District, or on some other basis as determined to be appropriate by the Board of Directors. Costs and expense of all charges, including Board-authorized annexation and detachment fees, shall be the obligation of the landowner(s) requesting such change.

XXIII. Severability and Breach:

Each article of these Bylaws is separate and distinct and the determination by a court or regulatory agency that any provision hereof is unenforceable shall not in any manner restrict or affect the remaining provisions.

Failure by the District to enforce or restrain the breach of any provision of these Bylaws or its applicable rules, shall not be construed as an estoppel or a waiver of any rights of enforcement the District may possess in the future or as a modification of said Bylaws or rules.

WESTERN CANAL WATER DISTRICT

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7.10.3 Agricultural Water Measurement Compliance Documentation

Documentation of WCWD's compliance with Section 10608.48(b) of the California Water Code (CWC §10608.48(b)) and the resulting California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 et seq. (CCR 23 §597) is provided on the following pages.

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Western Canal Water District

California Code of Regulations Title 23 §597

Agricultural Water Measurement Compliance Documentation

Executive Summary

Western Canal Water District (WCWD, or District) supplies water from the Feather River to over 50,000 acres of land in agricultural production and is required by law to comply with the measurement requirements of Section 10608.48(b) of the California Water Code (CWC §10608.48(b)) and the resulting California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 et seq. (CCR 23 §597). CWC §10608.48(b) states that agricultural water suppliers subject to the law, such as WCWD, are mandated to measure the volume of water delivered to customers with sufficient accuracy to:

- Enable reporting of aggregated farm-gate delivery data to the State and
- Adopt a pricing structure based at least in part on the quantity of water delivered.

CCR 23 §597 describes the accuracy requirements for the measurement of farm-gate deliveries, which fall into three different categories with corresponding accuracy requirements, as follows:

- ±12 percent by volume for existing devices certified in the field (i.e. field testing),
- ±10 percent by volume for new devices certified in the field using a non-laboratory certification (i.e. field testing or field inspection), and
- ±5 percent by volume for new devices certified in the laboratory (i.e. laboratory certification).

The regulation mandates that an accuracy certification be performed by either: (1) field testing of a random and statistically representative sample of existing or new farm turnouts, (2) field inspections and analysis of every existing farm turnout, or (3) a laboratory certification. The field testing and field inspection based accuracy certifications must documented in a report approved by a California-registered professional engineer.

From its inception in 1984, WCWD has used propeller meters to measure farm-gate deliveries and has billed customers using a volumetric pricing structure based on the quantity of water delivered. In order to determine whether or not the delivery measurement program was compliant with the requirements

of CCR 23 §597, WCWD elected to perform field testing of its existing devices. A California-registered professional engineer performed field testing (i.e. field verification measurements) on a statistically representative sample consisting of 11 percent (n = 34) of the entire population of measurement devices that the District currently uses for measurement (N = 303).

The average percentage difference between delivery volumes reported by the meters and verification measurements was negative seven percent, meaning that the recorded meter measurements tended to be seven percent lower by volume than the verification measurements. Out of the 34 meters tested, 29 (85% of the sample) had a percent difference of less than ±12 percent, while five (15% of the sample) had a percent difference greater than ±12 percent; therefore, the number of meters outside the accuracy requirements was less than one quarter of the devices tested. CCR 23 §597.4(b) states that no more than one quarter of the devices tested can have measurement errors greater than ±12 percent. Thus, existing volumetric delivery measurement by WCWD satisfies the requirements of CCR 23 §597.

The remainder of this document provides a more detailed description of volumetric delivery measurement by WCWD as detailed in CCR §597.4(e) and includes the following subsections:

- 1. Documentation of Compliance (CCR §597.4(e)(1)) - Review of requirements of CWC §10608.48, description of delivery measurement program, volumetric pricing structure, field testing methodology, and field testing results;
- 2. Best Professional Practices (CCR §597.4(e)(2)) - Description of best professional practices for maintaining delivery measurement program including collection of water measurement data, frequency of measurements, method of determining irrigated acres, and quality control and assurance procedures;
- 3. Determination of Volume (CCR §597.4(e)(3)) - Summary of procedure for determination of volume;
- 4. Corrective Action Plan Summary (CCR §597.4(e)(4)) - Explanation that no corrective action plan is required since current measurement program is compliant; and
- 5. References.

1. Documentation of Compliance (CCR §597.4(e)(1))

1.1. Review of §10608.48 Agricultural Water Measurement Requirements

Agricultural volumetric delivery measurement requirements are outlined in the Section 10608.48(b) of the California Water Code (CWC §10608.48(b)). A review of the requirements and associated legislation and regulations are contained in this section.

The Water Conservation Act of 2009 passed by the California State legislature consists of four policy bills and an $11.14 billion water bond. One of the policy bills (Senate Bill x7-7, or SBx7-7) addresses both urban and agricultural water conservation and, with respect to agriculture, includes new mandates regarding the accuracy of customer delivery measurement applicable to agricultural water suppliers serving more than 25,000 acres. WCWD serves water to over 50,000 acres and is therefore subject to the regulation.

The California Department of Water Resources (DWR) was responsible for developing and adopting regulations pursuant to SBx7-7, resulting in California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 et seq. (CCR 23 §597). CCR 23 §597, referencing CWC §10608.48(b), states that agricultural water suppliers subject to the law shall measure the volume of water delivered to customers with sufficient accuracy to:

- Enable reporting of aggregated farm-gate delivery data to the State, and
- Adopt a pricing structure based at least in part on the quantity of water delivered.

CCR 23 §597 describes the accuracy requirements for the volumetric measurement of farm turnout[1] deliveries, which fall into three different categories with corresponding accuracy requirements, as follows:

- ±12 percent by volume for existing devices certified in the field (i.e. field testing),
- ±10 percent by volume for new devices certified in the field using a non-laboratory certification (i.e. field testing or field inspection), and
- ±5 percent by volume for new devices certified in the laboratory (i.e. laboratory certification.

The regulation requires that an accuracy certification be performed by either: (1) field testing of a random and statistically representative sample of existing or new farm turnouts, (2) field inspections and analysis of every existing farm turnout, or (3) a laboratory certification. The field testing and field inspection based accuracy certifications must documented in a report approved by a California-registered professional engineer.

[1] The use of "farm turnout" and "turnout" in this document is synonymous with "farm-gate" and "customer delivery point" utilized in CCR 23 §597.

1.2. Delivery Measurement Program

WCWD was formed by a vote of landowners on December 18, 1984, and was previously owned by the Pacific Gas and Electric Company (PG&E). From its inception, propeller meters have been used extensively by the District to measure deliveries to customers. Currently all delivery points are measured as documented below.

Propeller meters are devices that measure both flow rate (cfs) and accumulated volume (af) over time with a totalizer. The District currently uses 303 propeller meters, including 267 (88%) are open channel propeller meters used where gravity deliveries are made and 36 (12%) lift pump propeller meters used where lift pump deliveries are made. The meters are deployed at delivery points across the District wherever control is transferred from the District to the customer(s), as described in CCR 23 §597.2(a)(6).

A typical WCWD farm turnout with gravity delivery is shown in Figure 1. An orifice gate is installed on the upstream side of the turnout for flow control. A concrete headwall is installed on the downstream side, allowing for the installation of an open channel propeller meter mounted in the outfall of the pipe. In locations where differences between the canal water surface elevation and the field elevation are large, a concrete weir box is installed on the downstream side to allow full-pipe flow, which is necessary for accurate delivery measurement. Figure 2 displays a photograph of an open channel propeller meter deployed in a concrete weir box in WCWD.

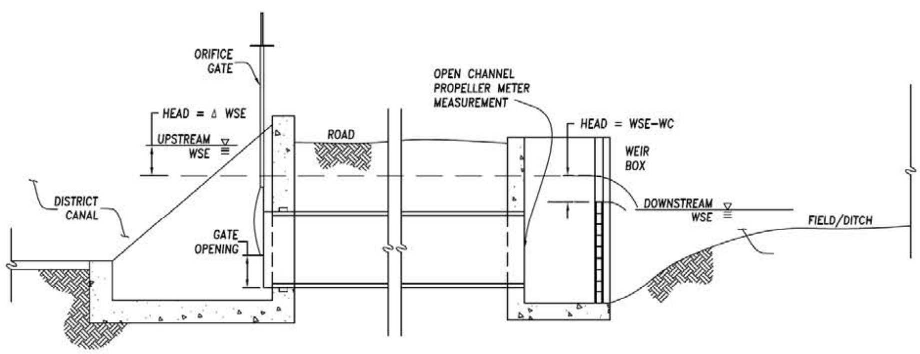

Figure 1. Typical Gravity Delivery Farm Turnout Configuration.

Figure 2. Open Channel Propeller Meter in WCWD.

Low lift pumps are utilized at locations where gravity deliveries are not possible to deliver water to fields. Lift pump propeller meters are used to measure deliveries in these locations and are inserted directly into the pipeline downstream of the pump. A 45° elbow or other device, as needed, is installed facing upwards in the outfall of the pipe to ensure full-pipe flow (necessary for accurate delivery measurement). Figure 3 displays a photograph of a lift pump propeller meter in WCWD, along with a Prosonics 92T transit-time flow meter used for field testing, which is further described in Section 1.4.

Figure 3. Lift Pump Propeller Meter in WCWD.

Both open channel and lift pump propeller meters are designed to measure flow rate and volume for a specific pipe diameter. The pipe sizes for the 303 meters currently in use at WCWD range from 8 inches to 36 inches. 260 of the meters (approximately 85% of the District's meters) are used in pipes at least 18 inches in diameter. Of the remaining meters, the most common size is 12 inches. The most common pipe and meter size is 24 inches, representing over 90 meters (approximately 30% of the meters used).

Operators visit each meter site at least once daily during the irrigation season to record flow rate and delivered volume and to ensure meters are functioning correctly. Approximately one third of the meters in the District are tested and calibrated annually at WCWD's meter testing facility along Little Dry Creek west of the District's office. The District allocates funds to purchase approximately 10 to 20 meters annually to replace damaged or defective meters. CCR 23 §597 compliance documentation for WCWD's delivery measurement program is provided in Section 1.5.

1.3. Volumetric Billing

Since its formation in 1984, WCWD has billed water users within the District using a wholly volumetric water rate. A minimum charge of one af/ac is billed for service annually, regardless of the volume of water delivered. Any water delivered in excess of one af/ac is billed based on the additional volume delivered. This pricing structure is compliant with the requirements of CWC §10608.48 and CCR 23 §597.

1.4. Field Testing Methodology

CCR 23 §597.4(b)(1) requires testing a minimum sample size of 10% of existing measurement devices. Because the turnout infrastructure and measurement devices being tested predate the regulation, they are required to have an accuracy of ±12 percent by volume. If more than one quarter of the devices fail to meet the accuracy requirements, the measurement program does not meet the requirements of the regulation, and a plan for a second round of field testing and corrective action would need to be developed. The methodology used to test a random and statistically representative sample of existing farm turnouts is described in the remainder of this section. Field testing results are presented in Section 1.5.

There are three alternatives[2] for compliance with the delivery measurement accuracy requirements of CCR 23 §597.3, as described previously in Section 1.1:

- Field testing of a random and statistically representative sample of existing farm turnouts,
- Field inspections and analysis of every existing farm turnout, or
- Referencing a laboratory certification.

In order to determine whether or not the delivery measurement program is compliant with the requirements of CCR 23 §597, WCWD elected to perform field testing. A California-registered professional engineer performed field testing (i.e. field verification measurements) on a statistically representative sample consisting of 11 percent (n = 34) of the entire population of measurement devices currently used for measurement (N = 303).

To obtain a randomized list of meters in WCWD, the District's complete meter list was assembled in a Microsoft Excel spreadsheet. The 'RAND()' function was used to generate a random value between zero and one for each meter. The meter list was then sorted in ascending order by the column containing the random value, creating a randomized list of meters.

Field testing was performed by a California-registered professional engineer over the course of four days on 5/13/2014, 5/14/2014, 5/21/2014, and 5/22/2014. Sites were selected from the randomized meter list from top to bottom; verification measurements were performed for each meter that was currently measuring an irrigation delivery. If the meter selected from the randomized meter list was not measuring an irrigation delivery, the next meter was selected. This process continued until a sample size of at least 10% of the meters had been tested. The resulting dataset was analyzed to ensure that it was statistically representative.

The procedure taken for each field testing (i.e. verification) measurement was:

[2] The first two of the three alternatives are required to be documented by a California-registered professional engineer.

- Upon arrival to the site, a flow reading was taken from the propeller meter by timing the meter for 60 seconds and counting the number of rotations. The meter flow chart, which is shown in Figure 4, was then used to determine the flow rate.
  - For 10" to 18" meters, each revolution is 0.72 cfs.
  - For 21" to 36" meters, each revolution is 7.2 cfs.

Open Flow Meters

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.00	0.07	0.14	0.22	0.29	0.36	0.43	0.50	0.58	0.65
1	0.72	0.79	0.86	0.94	1.01	1.08	1.16	1.22	1.30	1.37
2	1.44	1.51	1.58	1.66	1.73	1.80	1.87	1.94	2.02	2.09
3	2.16	2.23	2.30	2.38	2.45	2.52	2.59	2.66	2.74	2.81
4	2.88	2.95	3.02	3.10	3.17	3.24	3.31	3.38	3.46	3.53
5	3.60	3.67	3.74	3.82	3.89	3.96	4.03	4.10	4.18	4.25
6	4.32	4.39	4.46	4.54	4.61	4.68	4.75	4.82	4.90	4.97
7	5.04	5.11	5.18	5.26	5.33	5.40	5.47	5.54	5.62	5.69
8	5.76	5.83	5.90	5.98	6.05	6.12	6.19	6.26	6.34	6.41
9	6.48	6.55	6.62	6.70	6.77	6.84	6.91	6.98	7.06	7.13
10	7.20	7.27	7.34	7.42	7.49	7.56	7.63	7.70	7.78	7.85
11	7.92	7.99	8.06	8.14	8.21	8.28	8.35	8.42	8.50	8.57
12	8.64	8.71	8.78	8.86	8.93	9.00	9.07	9.14	9.22	9.29
13	9.36	9.43	9.50	9.58	9.65	9.72	9.79	9.86	9.94	10.01
14	10.08	10.15	10.22	10.30	10.37	10.44	10.51	10.58	10.66	10.73
15	10.80	10.87	10.94	11.02	11.09	11.16	11.23	11.30	11.38	11.45
16	11.52	11.59	11.66	11.74	11.81	11.88	11.95	12.02	12.10	12.17
17	12.24	12.31	12.38	12.46	12.53	12.60	12.67	12.74	12.82	12.89
18	12.96	13.03	13.10	13.18	13.25	13.32	13.39	13.46	13.54	13.61
19	13.68	13.75	13.82	13.90	13.97	14.04	14.11	14.18	14.26	14.33

Size 10" to 18" read as shown - Size 21" to 36" move decimal to right one point.

Figure 4. Meter Flow Chart.

- For gravity sites, the following verification measurement was performed:
  - The meter was temporarily removed, since the verification measurement also takes place in the pipe outfall.
  - The recorded pipe diameter and full-pipe flow were verified.
  - A SonTek FlowTracker Acoustic Doppler Velocimeter (ADV) was used to perform a velocity transect in the outfall of the pipe, wherein a distribution of velocity points were measured horizontally and vertically across the pipe as seen in Figure 5.
  - Flow rate was calculated as the product of the average velocity from the measurement transect and the pipe cross-sectional area determined from the inner pipe diameter. The accuracy of this measurement method has been demonstrated by a study comparing this method to the conventional USGS mid-section method (Thiede and Davids 2012).
  - The propeller meter was reinstalled after the verification measurement was complete.

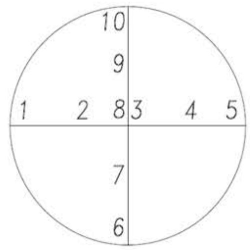

Figure 5. Velocity Transect Measurement Locations.

- For lift pump sites, the following verification measurement was performed:
  - The pipe material, diameter, and thickness were verified.
  - An Endress+Hauser Prosonics 92T Portable Transit-Time Ultrasonic (Prosonics) flow meter was used to perform a verification flow measurement with a two pass (i.e. "V") configuration.
  - A five minute average from the Prosonics flow meter was used as the verification measurement.
- Upon completion of the verification measurement, another flow reading was taken from the propeller meter as described above.
- The average of the two propeller meter readings was compared to the verification measurement to determine measurement device accuracy.

1.5. Field Testing Results

This section describes the results of the field testing effort. Over the course of four days of field testing, a total of 34 existing measurement devices were tested for accuracy as described in Section 1.4. A combination of open channel propeller meters and lift pump propeller meters were tested, with pipe sizes ranging from 12 inches to 36 inches in diameter. The most common meter size tested was 24 inches. The 34 meters (n = 34 or 11%) constitute a randomly selected, and statistically representative sample of the 303 meters (N = 303) in WCWD (as outlined in Section 1.4 in greater detail).

The flow rates measured during the verification measurements ranged from 0.94 cfs to 23.1 cfs with an overall average of 6.85 cfs. The percent difference for each individual meter was calculated using Equation 1, and the average percent difference was then calculated as the arithmetic mean of all 34 verification measurements.

$$\%\,Difference = \left(\frac{Meter\ Reading - Verification\ Measurement}{Verification\ Measurement}\right) \times 100\% \qquad [1]$$

The average percentage difference between the meters and verification measurements was negative seven percent, meaning that the recorded meter measurements tended to be seven percent lower than the verification measurements. Out of the 34 meters tested, 29 (85% of the sample size) had a percent difference of less than ±12 percent, while five (15% of the sample size) had a percent difference greater than ±12 percent; therefore, the number of meters outside the accuracy requirements was less than one quarter of the devices tested. CCR 23 §597.4(b) states that no more than one quarter of the devices tested can have measurement errors greater than ±12 percent. Thus, existing volumetric delivery measurement by WCWD satisfies the requirements of CCR 23 §597.

2. Best Professional Practices (CCR §597.4(e)(2))

The delivery measurement program was verified to be compliant based on field testing during May 2014; however, in order to maintain compliance, current monitoring and maintenance activities related to volumetric delivery measurement need to continue including but not limited to practices to collect data, perform frequent measurements, and accurately determine irrigated acreage, and ensure quality control and quality assurance. This section describes best professional practices to be continued as part of WCWD's delivery measurement program to satisfy the requirements of CCR 23 §597.

2.1. Collection of data

In WCWD, volumetric delivery measurement data is collected using open channel propeller meters for gravity deliveries and lift pump propeller meters for lift pump deliveries. These are devices that measure both instantaneous flow rate (cfs) and volume (af). Flow rate measurements can be taken from meter readings while an operator is on site, using the procedure described above in Section 1.4. Delivered volume is determined on a continuous basis using a totalizer that records accumulated volume over time and can be read from the meter while on site.

2.2. Frequency of Measurements

During the irrigation season, operators visit each meter site at least once daily to record flow rate measurements and volumetric totalizer readings, and ensure meters are functioning correctly. This practice should be continued.

2.3. Method of Determining Irrigated Acreage

Irrigated acreages in the District are provided through the Farm Service Agency (FSA). When customers submit annual applications for water service, they are required to report FSA acreages. Acreages are updated and reviewed annually. This practice should be continued.

2.4. Standards for Quality Control and Quality Assurance

Daily visits to meter sites during the irrigation season are a key component of quality control and quality assurance practices. These visits allow problems with meters to be quickly identified so that steps can be taken to correct any problem in a timely manner. Frequent visits minimize uncertainties in volumetric delivery measurement. Also, maintaining a daily record of both instantaneous flow rate and accumulated volume provides a consistent record over time that can be used for quality control purposes. For example, if the totalizer on a meter malfunctions; this results in a decrease in the rate of accumulated volume. The daily flow rate and volume records can be used to identify the malfunction, and the daily flow record can be used to adjust the volumetric delivery record in place of the faulty totalizer reading. When this occurs, adjustments are summed on a two week basis and added to the difference between the beginning and ending totalizer readings. In the event of a damaged or defective meter, the meter should be replaced as soon as possible.

Approximately one third of the meters in the District are tested and calibrated annually at WCWD's meter testing facility along Little Dry Creek west of the District office, and the District allocates funds to purchase approximately 10 to 20 meters annually to replace damaged or defective meters. These practices should be continued.

3. Determination of Volume (CCR §597.4(e)(3))

CCR 23 §597 states that for water measurement devices that measure flow rate, velocity, or water elevation and do not report the total volume of water delivered, the conversion from the measured value to volume must be documented. There are uncertainties associated with conversions from instantaneous measurement to accumulated volume over time; however, the totalizers on the meters used by WCWD report the total volume of water delivered. For permanently installed devices with totalizers, such as the meters used by WCWD, it can be assumed that flow rate accuracy is equal to volumetric accuracy (Burt and Geer 2012).

4. Corrective Action Plan (CCR §597.4(e)(4))

Because existing volumetric delivery measurement by WCWD satisfies the requirements of CCR 23 §597, no corrective action is necessary.

5. References

Burt, C., E. Geer, 2012, 'SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts,' ITRC Report No. R 12-002, accessed at http://www.itrc.org/reports/pdf/sbx7.pdf.

Thiede, M.T., J.C. Davids, 2012, 'Evaluation of Weir Boxes and Orifice Gates for Farm Gate Delivery Measurement,' U.S. Committee on Irrigation and Drainage, Managing Irrigation Systems in Today's Environment, USCID Water Management Conference, Reno, NV.

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7.10.4 Potential Projects to Enhance Water Management Capabilities

A description of potential projects to enhance WCWD water management capabilities is provided on the following pages. Some of these projects have been implemented in the time since

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Potential Projects to Enhance WCWD Water Management Capabilities

Overview
A total of three potential projects to enhance water management by Western Canal Water District (WCWD) were evaluated. These range from comprehensive system modernization to localized projects related to boundary outflow and safety spill measurement. Also, a project to bypass the "reservoir" area in the Main Canal at Little Butte Creek was evaluated. For each project, reconnaissance level implementation costs have been estimated. It is anticipated that these projects would be implemented over time subject to the availability of funding and project prioritization. Potential improvements are described in the following sections:

1. System Modernization
2. Boundary Outflow and Primary Spill Measurement
3. Little Butte Creek Reservoir Main Canal Bypass Project

Summary of Cost Estimation Procedure
Reconnaissance level cost estimates were prepared for each improvement project as a basis for prioritization and funding of site improvements. The following summary of the cost estimation procedure applies to all projects described in this attachment.

Site inventories were completed with the help of district staff, and sites were visited as needed to provide sufficient information to develop conceptual designs to estimate material and labor quantities. Detailed site surveys have not been performed, and dimensions of structures and cross sections were gathered only at a sample of locations. Based on field visits, many sites of a specific type (e.g. water level control) were similar, varying primarily in capacity. Accordingly, conceptual designs were developed for each site type across a range of capacities. The typical components for which conceptual designs were developed are listed in Table 1. Costs were developed based on estimates of required site components, quantities, and unit costs.

Table 1. Typical conceptual designs and the variations/configurations developed for purposes of cost estimation.

	Typical Design	Variations/Configurations
A	Acoustic Doppler velocimeter in lined section of channel	
B	Acoustic Doppler velocimeter in unlined section of channel	I. High capacity canal II. Mid-range capacity canal
C	New Precast Spill Box with 36" propeller meter at d/s end	I. 4 ft weir box II. 6 ft weir box
D	Precast headwall with new 36" undershot gate, piping and propeller meter at d/s end	
E	New Precast Spill Box with fixed, sharp-crest weir plate	I. 4 ft weir box II. 6 ft weir box
F	New precast spill box with piping and RemoteTracker bracket at d/s end. RemoteTracker not included.	
G	Locally automated combination weir	450, 250, 150, 75, 50, and 25 cfs capacity
H	Manually Adjusted Undershot Gates	Cost estimated on a per square foot of gate area basis
I	Automated Flow Control Gates	Cost estimated on a per square foot of gate area basis
J	SCADA hardware and related communication components	I. No add'l power source II. No add'l power source, w/ PLC III. W/ solar power system and PLC IV. W/ solar power system, pressure transducer and related components

Unit Costs

Unit costs for the various work items and materials were compiled from a variety of sources including published values, local suppliers, contractors and installers, and projects previously completed by Davids Engineering and others. Standard unit prices were increased by 10% assuming prevailing labor rates will apply. Costs include material and equipment costs, installation labor, shipping, and tax (where applicable).

Cost types fall into three categories: Direct Costs, Indirect Costs, and Contingencies. Direct costs are associated with physical site improvements while indirect costs represent other project costs such as engineering and design, environmental permitting, construction management, administration and legal, and overhead and are included as a percentage of the sum of extended costs plus the contingency. Contingency is applied to the subtotal of direct costs based on uncertainties present at this level of design and cost estimation and to account for unforeseen requirements.

Total indirect costs plus contingency vary by site type to account for differences in site complexities, construction effort, engineering and design requirements, the source of the unit cost information, and professional judgment. Mark-ups are summarized in Table 2. All projects were assumed to be designed and constructed using competitive bidding processes. It is likely that several of the site improvements could be implemented under a design-build scenario, or even by district forces, both of which might result in costs less than those presented herein.

Table 2. Summary of range of percentage multipliers applied to cost estimate to account for indirect costs and contingencies.

Range of Percentages Applied to Total Direct Costs			
Engineering & Construction Management	10%	to	20%
Legal, Environmental and Administration	0%	to	20%
Total =	10%	to	40%
Percentage Applied to Total Site Cost			
Contingency	10%	to	20%

Quantities

Canal capacities were determined through consultation with district operators or estimated using Manning's equation for open channel flow using a combination of measured and assumed cross section dimensions. For each canal the top water width was measured at several locations using the point-to-point utility in Google Earth. Canal water depths were estimated based on field observations. Average slopes along the canal lengths were estimated from Google Earth and USGS topographic maps. A Manning's roughness coefficient of 0.033 was used assuming excavated earthen canals, winding and sluggish with grass and some weeds, as defined in Te Chow (1959)[1]. Where available, calculated capacities were validated with measured capacities or typical peak diversions and globally adjusted as appropriate.

Quantities for larger structures were independently calculated and compared with conceptual structures designed for the Sutter Butte Regional Conveyance Study[2], conceptual structures in the WCWD Draft 20-Year Capital Improvements Plan, and 60% design cost estimates[3] for the BWGWD Gray Lodge Wildlife Area Supply Project.

Site Specific Improvement Costs

For each site, applicable designs and base cost estimates for typical sites were either used without modification, adjusted to reflect actual site conditions, or combined with components for other sites to create site specific improvement capital and annualized costs, as appropriate.

Annual Costs

Annual capital repayment was estimated for each item using an amortization rate of 5 percent and capital recovery factors calculated using the estimated expected life of each cost item. Total annual costs also include annual operations and maintenance (O&M) costs associated with the improvement. O&M costs were estimates as a percentage of the total extended cost of the item. The percentage ranged from 0 percent for items not requiring annual maintenance to 5 percent for electrical or mechanical components where more frequent O&M is necessary to ensure reliable operation and system longevity.

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[1] Te Chow, Ven. 1959. Open Channel Hydraulics. The Blackburn Press, Caldwell, New Jersey, U.S.A.

[2] GEI Consultants, 2006. Regional Conveyance System Improvement Project – Final Report, May 2006. Completed for Sutter Extension Water District by Bookman-Edmonston, a division of GEI Consultants, Inc.

[3] Engineer's Opinion of Probable Construction Cost, 60% Design. October 2011. Prepared by Provost and Pritchard Consulting Engineers.

Project 1: System Modernization

Project Description

The proposed system modernization project aligns with WCWD's proactive stance on the replacement and improvement of existing infrastructure, the development of data to evaluate existing operations and potential future water management improvements, and the development and implementation of management strategies and tools to meet water management objectives including water conservation at the district scale and improved delivery service to customers.

System modernization is generally implemented to achieve one or more of the following goals:

1. Increase the efficiency of the distribution system to conserve water at the district scale,
2. Increase the efficiency of the distribution system to irrigate additional land,
3. Increase the level of service provided to growers and respond to changes in cropping or irrigation method,
4. Reduce risks to the safety of operations staff, and
5. Improve the overall operability and management of the District.

A comprehensive modernization plan provides a road map for a phased implementation that allows for improvements to occur over time at a pace that considers available funds and prioritization of improvements to meet objectives in the most beneficial manner possible. Sites within each phase may be completed all at once, or on a prioritized basis, but would generally begin at the head of the system and proceed downstream to maximize benefits relative to implementation costs. The system modernization strategy developed for WCWD involves four phases with flow measurement being an overarching improvement. It is anticipated that the actual sequence of improvements to individual sites may differ from those described herein as informed by evaluation of opportunities, costs, and other considerations over time.

The system modernization program generally includes improvements to three site categories: heading structures, upstream water level control structures, and spill structures. The objectives for each of these site categories is described in Table 3.

Table 3. System Modernization Objectives by Site Category.

Site Category	General Modernization Objective
Heading	• Replace old, aging and/or deteriorated structures and equipment, as needed. • Provide increased accuracy, repeatability, and consistency in downstream deliveries to district customers to reduce farm runoff and tail end spills. • Improve the ability to make flow adjustments to prevent spill and enhance delivery service. • Increase safety of site for operators.
Upstream Water Level Control	• Replace old, aging and/or deteriorated structures and equipment, as needed. • Maintain steady upstream deliveries by reducing fluctuation in upstream water levels over a range of canal flow rates. • Simplify operations by reducing the need to add or remove flashboards to maintain water levels across a range of flows. • Facilitate the ability to make frequent flow changes through the system, as needed. • Consolidate safety spills by eliminating intermediate safety spills, where practical. • Increase safety of site for operators.
Spills	• Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback on heading operation, general lateral operation, and District water accounting. • Increase safety of site for operators.

The specific improvements completed under each of the four phases of modernization are described in additional detail below.

Phase I System Modernization

The first phase would concentrate on primary inflow and operational outflow locations. These are generally the primary diversion locations or headings (heading gates from the afterbay, etc.) and primary outflow points. The type and sophistication of improvements required to meet objectives varies by site, but the general objective is to provide improved control over the water that enters the district, as informed by improved information describing the timing and amount of water leaving the district. Readily accessible measurement of inflows and outflows has several benefits, including information to inform operational adjustments, data for water accounting and billing, and information to support prioritization of additional improvements by quantifying potential benefits.

For WCWD, the primary inflow point is the Western Canal at Thermalito Afterbay which has an approximate capacity of 1,200 cfs. Currently, WCWD contacts the California Department of Water Resources (DWR) operations staff for daily changes in inflow. Flows into the Western Canal are measured by DWR in the WCWD canal downstream of the heading with no secondary measurement to verify released flows. Fluctuations in afterbay water levels can cause fluctuations in delivered flows. Accurate flow measurement at primary inflow locations is important to achieve water management objectives because it allows for more accurate and precise management of inflows to the distribution system. Recommended improvements at the heading include installation of new flow measurement that would be remotely monitored by the district operations manager and operators for improved operations and accounting. In addition to physical improvements, it is anticipated that protocols would be developed in consultation with DWR to allow more precise and potentially more frequent adjustments to releases to better match demands and increase operational efficiency.

501 Main Drain Outflow to Butte Creek

The primary operational outflow locations in WCWD are the ends of the Ward Canal at the 501 Main Drain and the 1656I spill site at the end of the Main Canal. Being at the bottom end of the system, these two outflow locations include the majority of the operational spillage from the system downstream of the “reservoir”. Following rerouting of spills in later modernization phases, these sites will see greater concentration of remaining spills. Additionally, operational spills at the Butte Creek Spill and return flows from the Pratt Lateral (Fenn Drain) would benefit from measurement and remote monitoring and help inform operations as well as future phases of modernization.

Phase II System Modernization

The second phase of modernization would improve key control points along the main supply canal between the headings and outflows to increase conveyance efficiency. This would include main canal water level control structures and lateral headings. Existing control structures may be abandoned in some cases, re-configured, retrofitted, downsized, or retained. WCWD has initiated modernization in this regard and replaced three existing check structures (535 Check, 875 Check, and 1190 Check) with locally automated Langemann Gates and is currently planning to replace the Nelson check structure[4]. The addition of Phase II improvements to Phase I improvements would generally provide steadier delivery of water from the main canal to laterals and turnouts, simplify operations by adding automation to increase the ability to make flow changes, and concentrate primary routing of flow fluctuations along the main canal.

In WCWD (as in most open canal systems) the remaining structures are flashboard check structures that require adjustment whenever there is a flow change to avoid impacts to deliveries to upstream laterals and turnouts. Without adjustment, water level fluctuations can reduce the steadiness of these flows. In addition to impacting service, these fluctuations present challenges to water accounting and may result in operators storing “extra water” in certain canal reaches as a buffer for when deficiencies occur. This water may ultimately spill if not needed.

The modernization strategy for WCWD is to provide new check structures that can pass flow fluctuations downstream while maintaining upstream water levels across a range of flows with limited fluctuation. In order to function over a wide range of flows, new check structures would incorporate locally

[4] It is anticipated that the structure will be replaced in January 2015.


875 Check Structure on Main Canal

automated overshot gates. For purposes of the reconnaissance level cost estimates presented herein, several capacities of check structures were conceptually designed ranging from 1,200 cfs (634 and 702 Checks) to 600 cfs at the 1152 Check. The use of adjustable overshot gates provides a more flexible range if flows with better performance than fixed crest structures and would allow the upstream water depth to be minimized to reduce seepage during rice field dry-down periods (i.e., August and September) but when deliveries for waterfowl habitat are desired.

A key focus of the modernization process is to select how and where flow fluctuations in excess of demands should be routed through the system. Consolidation and routing of fluctuations along one primary route increases the likelihood that they can be used to meet downstream demand, and allows for simplified monitoring of system operations to inform adjustments to diversions and upstream structures to reduce spillage. The ability to route flow fluctuations effectively is currently limited in some cases because many canal structures are unable to quickly pass fluctuations. As a result, the use of intermediate safety spills (such as Butte Creek Spill) that provide temporary relief is required until flashboard adjustments can be made in the Western Canal. The Butte Creek Spill site is currently a point of reregulation when used in conjunction with the downstream radial gate used for flow control. Following improvement, the radial gate would operate in upstream water level control and reduce the need for the spill to be a reregulation point.

In addition to passing flow fluctuations downstream, new overshot-style water level control structures would enable steadier deliveries to laterals and turnouts supplied by the main canal by essentially fixing the upstream water level; however, upstream water level control is only part of the solution to maintain constant delivery rates. Improvement of lateral headings (including private headings) along the Western Canal is additionally recommended. These improvements would include new adjustable undershot gates and flow measurement. The recommended measurement approach for lateral headings depends on the frequency of use and lateral size. In general, smaller, less frequently used laterals are measured using propeller meters. Acoustic Doppler flow meters with continuous measurement capability are recommended for larger laterals.

The improvement of check structures and lateral headings along the Western Canal as described herein would establish the canal as the primary spill route. Figure 1 provides an overview of all proposed improvement sites.

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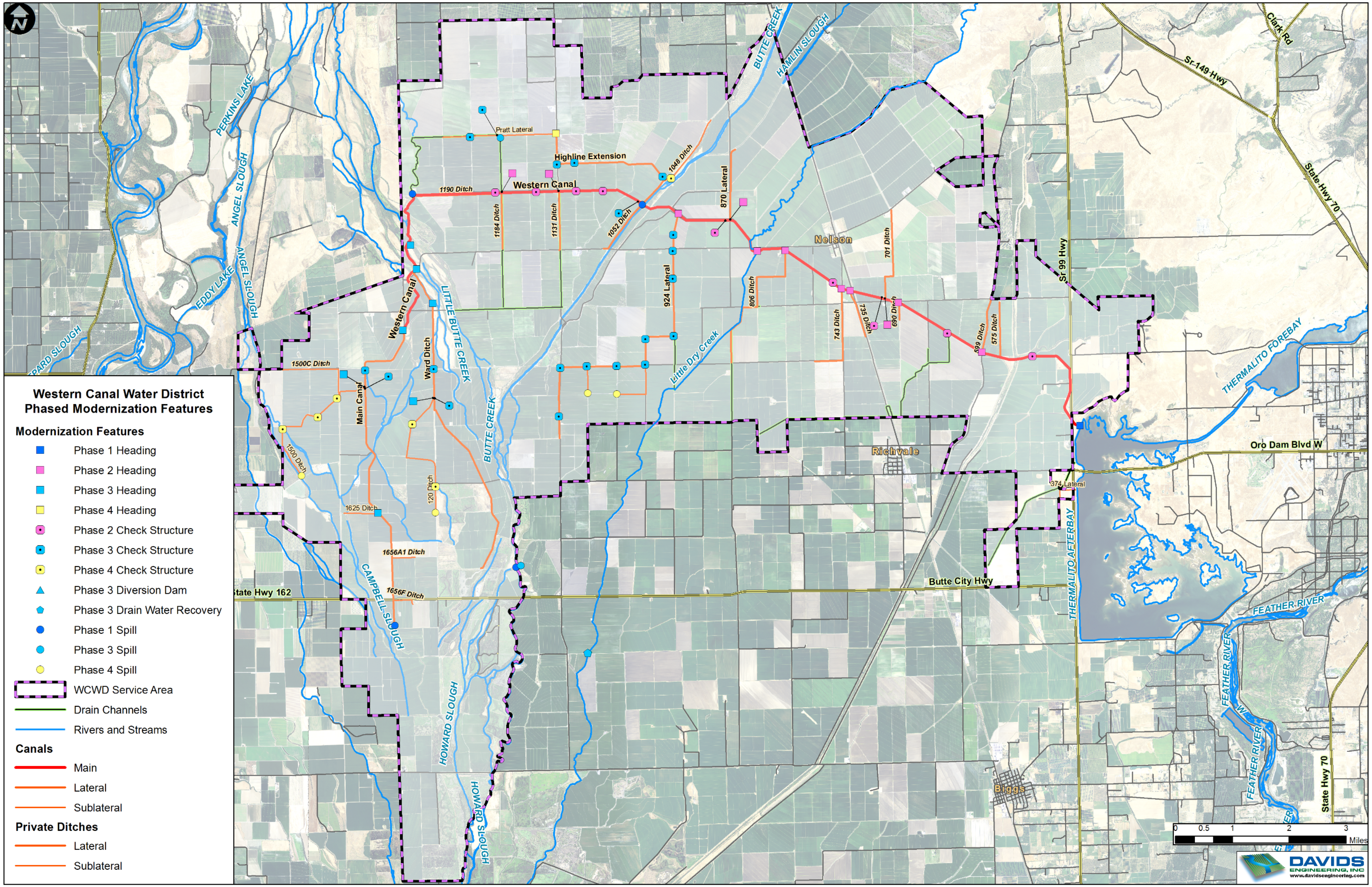

Figure 1. WCWD System Modernization Phasing and Improvement Sites.

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Phase III System Modernization
To extend benefits to deliveries from the laterals, Phase III would improve primary lateral control structures and end spills to further improve controllability. Additionally, improved routing of flow fluctuation to the Main Canal and Ward Ditch would be accomplished, consolidating spills to the 1656I spill and the 501 Main Drain. The Main Canal and Ward Ditch heading structures both receive water from the tail end of the Western Canal via an area referred to as the "reservoir." The reservoir is an impounded section of Little Butte Creek that receives inflows from Western Canal on the east and conveys water to the Main and Ward Laterals to the west. This site poses several challenges, including:

1. Operation of the Front and Back slide gates to impound the creek and provide conveyance through pond storage requires the use of 59 individual 5 ft by 5 ft metal gates. Gates must all be raised/removed following the irrigation season to accommodate storm flows.
2. The relatively flat topography requires a significant incoming volume to increase water depth and conveyance capacity.
3. Normal upstream inflows in Little Butte Creek can cause unexpected fluctuations in inflows to the Main and Ward laterals.
4. Measurement of inflows to the Main and Ward canal headings requiring significant judgment by operators.

The modernization project would replace the existing Main and Ward canal headings with automated flow control gates and new concrete structures to enable constant flow to meet downstream demand, regardless of the upstream water level fluctuations. To improve operational efficiency and operator safety during the seasonal opening and closing of the Front Slide Gates, existing gates would be fitted with gear operated cable hoists and gate slides refurbished to minimize friction. The Front Slide Gates would be operated to function solely as a diversion dam during the irrigation season. The Back Slide Gates would provide upstream water level control for the upstream diversion. Replacement of several of the existing rectangular slide gates with locally automated radial gates would increase upstream delivery steadiness and reduce operational effort while enabling free, unimpaired flow during the off-season.

Spill routing within primary laterals would also be completed under Phase III. Replacing existing check structures along these routes with long crested weirs would provide steady upstream water levels with no adjustment required. Because of the long weir length, a large change in flow would result in only a small change in head enabling more rapid transfer of flow fluctuations down the system because the change in upstream pond storage to pass the change would be minimized. Laterals that would be improved under Phase III include the Main Canal, Ward Ditch, 1500 Ditch, 1625 Ditch, W120 924 Ditch, Highline Extension, and Pratt Lateral.

Phase IV System Modernization
The fourth modernization phase would build upon lateral heading flow control completed under Phases II and III and lateral water level control completed under Phase III by improving secondary control structures along laterals and sublaterals to inform and improve operations. Additionally, minor or secondary safety spills are prioritized for improvement although some intermediate safety spills would likely not be needed and could be abandoned as check structures are improved to allow routing of flow fluctuations without causing substantial water level fluctuations, capacities are increased, and the

controllability of flows at heading structures is increased. Objectives are to increase flexibility, consistency, and adequacy of supply to sublaterals; increase delivery steadiness and consistency; and concentrate routing of flow fluctuations to a designated location with measurement to provide operators with feedback to help determine the need for a changes at lateral headings to improve operations. The final phase would include additional improvements to the 1500 ditch, W120 ditch, Skinner Dam, and several minor spills.

Inventory of Existing Conditions

Existing conditions were characterized through consultation with District staff and digitally inventoried in tabular form and in an interactive mapping format. For each site type, representative sites were selected for field inspection to obtain dimensions, coordinates, photos and operational features typical of the site type to aid in strategy development and cost estimation. These sites included primary control points. Table 4 provides the site name, the site type, latitude, longitude, and a description of existing conditions for each site to be improved under the System Modernization project. Sites were assigned to one of the following categories: Inflow, Heading, Water Level Control, or Safety Spill. The system modernization plan described herein focuses on primary and secondary control points and other system components and may not be exhaustive.

Table 4. Inventory of Existing Conditions.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
Western Canal Heading	Inflow	39.51	-121.69	Remotely controlled gates for inflow to Main Canal from Thermalito Afterbay. Gates controlled by California DWR operators.
Butte Creek Spill	Spill	39.56	-121.83	Concrete overpour structure spills water as levels rise above crest. Designed to pass 200 cfs. Two undershot gates used for delivery to Butte Sink during Fall. Manual measurement of spill over pour three times per day.
501 Main Drain Outflow to Butte Creek	Spill	39.47	-121.87	Structure holds water level for upstream deliveries. Concrete abutments with several manually adjusted flashboard bays. Steel catwalk spans structure. Approximately 2ft of drop through structure.
1656I Spill	Spill	39.46	-121.91	Precast weir box with adjustable boards and short section of pipe on downstream end. Structure holds a level pond for several upstream pumped deliveries. Excesses spill northeast-ward to slough.
Pratt Lateral Return Flow (Fenn Drain)	Inflow	39.57	-121.91	Return flows to the Western Canal from Pratt Lateral spill points, and also spills from Fenn deliveries. Meandering earthen cross section of various widths. Culvert road crossing just upstream from return flow to Western Canal.
535 Check Structure	Water Level Control	39.52	-121.7	Concrete structure with two 18' wide Langemann Gates that operate under locally automated upstream water level control.
634 Check Structure	Water Level Control	39.53	-121.73	Concrete structure with ten manually adjusted flashboard bays

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
702 Check Structure	Water Level Control	39.54	-121.75	Concrete structure with ten manually adjusted flashboard bays
Nelson Check Structure	Water Level Control	39.54	-121.77	Concrete structure with two 16' wide Langemann Gates that operate under locally automated upstream water level control.[5]
Dry Creek Sidegates	Heading	39.55	-121.79	Concrete headwall with undershot gate just upstream from Dry Creek siphon. WCWD makes deliveries here for extraction downstream at Harris Dam and Dry Creek Dam.
870 Headgates	Heading	39.56	-121.8	Concrete headwall structure with three 36" diameter undershot gates.
875 Check Structure	Water Level Control	39.56	-121.8	Concrete structure with two 15' wide Langemann Gates that operate under locally automated upstream water level control.
924 Headgates	Heading	39.56	-121.82	Concrete headwall structure with 2 48" undershot gates. Total capacity is approximately 200 cfs.
1090 Check Structure	Water Level Control	39.57	-121.84	Concrete structure with eight manually adjusted flashboard bays
1115 Check Structure	Water Level Control	39.57	-121.85	Concrete structure with eight manually adjusted flashboard bays
1152 Check Structure	Water Level Control	39.57	-121.86	Concrete structure with eight manually adjusted flashboard bays
1190 Check Structure	Water Level Control	39.57	-121.88	Concrete structure with one 15' wide Langemann Gate that operate under locally automated upstream water level control.
599 Headgates (Private)	Heading	39.52	-121.72	Concrete headwall with undershot gate. Short section of pipe downstream of gate before discharging to ditch. Differential head calculations used for measurement
690 Headgates (Private)	Heading	39.54	-121.75	
701 Headgates (Private)	Heading	39.54	-121.75	Concrete headwall structure with two 36" undershot gates and one 30” undershot gate.
735 Headgates (Private)	Heading	39.54	-121.76	Concrete headwall with undershot gate. Short section of pipe downstream of gate before discharging to ditch. Differential head calculations used for measurement
743 Headgates (Private)	Heading	39.54	-121.76	Concrete headwall with three undershot gates.

[5] Improvements not yet completed at time of plan preparation. Expected to be completed in January 2015.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
806 Headgates (Private)	Heading	39.55	-121.78	Concrete headwall with undershot gate. Short section of pipe downstream of gate before discharging to ditch. Differential head calculations used for measurement
1052 Headgates (Private)	Heading	39.56	-121.83	
1131 Headgates (Private)	Heading	39.57	-121.86	
1184 Headgates (Private)	Heading	39.57	-121.88	
1190 Headgates (Private)	Heading	39.57	-121.88	
Highline Extension and Pratt Lateral Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
Butte Creek Radial Gate	Water Level Control	39.56	-121.83	Single 12ft wide radial gate in concrete structure. Typical flow range is 400 to 600 cfs. Currently used for flow control.
Back Slide Gates	Water Level Control	39.55	-121.91	Concrete and steel structure that spans slough. Approximately 200 ft wide made up of 5'x5' vertical steel undershot gates that are manually adjusted.
Front Slide Gates	Water Level Control	39.55	-121.9	Concrete and steel structure that spans slough. Approximately 150ft wide made up of 5'x5' vertical steel undershot gates that are manually adjusted.
Ward Heading	Heading	39.54	-121.9	Concrete headwall with undershot gates for flow control.
Main Heading	Heading	39.53	-121.91	Concrete headwall structure with several undershot gates for flow control. Currently limited to approximately 280 cfs.
Main Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
1500 Ditch Headgates	Heading	39.52	-121.92	Concrete headwall with manually operated undershot gate. Short section of pipe on discharge side conveys flow under canal levee to ditch.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
1625 Ditch Headgates	Heading	39.49	-121.92	Concrete headwall with manually operated undershot gate. Short section of pipe on discharge side conveys flow under canal levee to ditch.
Ward Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
W120 Headgate	Heading	39.51	-121.9	Concrete headwall with manually operated undershot gate. Short section of pipe on discharge side conveys flow under canal levee to ditch.
924 Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Condition varies.
924L Spill	Spill	39.52	-121.84	Precast weir box with adjustable boards and short section of pipe on downstream end.
924O Spill	Spill	39.52	-121.85	
HL115 Spill	Spill	39.57	-121.86	
Dry Creek at Harris Dam (RID joint site)	Flow Control	39.48	-121.84	Six 48"wide flashboard bays in drain to west. Little Dry creek can either pass through/over structure to west (to Butte Creek) or continue south over shallow road crossing and Watt Canal siphon. Bridge over Little Dry Creek appears to collect debris
Little Dry Creek Spill	Spill	39.47	-121.87	Concrete headwall structure that spans the drain channel and increases the upstream water level. Manually adjustable weir boards dictate spill point.
1500 Ditch weirs	Water level control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
1500L Spill	Spill	39.5	-121.94	Precast weir box with adjustable boards and short section of pipe on downstream end.
W120 Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
W120GSpill	Spill	39.49	-121.9	Precast weir box with adjustable boards and short section of pipe on downstream end.
Pratt Headgates	Heading	39.58	-121.86	Two 48" undershot gates
Skinner Dam	Water Level Control	39.57	-121.82	Weir structure with adjustable weir crest that enables diversion of water from the Highline Extension canal for delivery to irrigators upstream along Butte Creek. Check structure creates level-top pool that can be pumped from.
P52 Spill	Spill	39.58	-121.88	Precast weir box with adjustable boards and short section of pipe on downstream end.

System Modernization Physical and Operational Improvements

Level 1 and 2 Improvements

For each site, improvement is split into two levels, Level 1 and Level 2. Level 1 improvements typically include fundamental infrastructure and measurement enhancements that are manually operated or read, or locally automated, and designed as SCADA-Ready[6]. These improvements include, but are not limited to new, manually adjustable heading gates; long crested weirs; locally automated overshot gates; and measurement devices such as weirs, acoustic Doppler flow meters, and propeller meters. Level 2 improvements build upon Level 1 improvements by automating certain additional features, adding electronic sensors, installing on-site digital display of flow rate or other parameters, or adding remote monitoring or control through a Supervisory Control and Data Acquisition System (SCADA). Level 1 improvements are stand-alone, while Level 2 improvements generally require Level 1 to be completed prior to or at the same time. The progression from level 1 to level 2 improvements provides the flexibility to complete Level 1 (which has significant benefits on its own) while assessing the benefits of SCADA, further prioritizing sites, establishing a SCADA base station, and gradually implementing potentially more complex and technically intricate remote control sites. In some cases, there could be capital cost savings by completing Level 1 and Level 2 improvements at the same time.

Although Level 2 is not universally required to substantially achieve water management objectives, several sites would benefit. Two examples of this are:

1. Remotely located end spill sites not frequently visited by operators. Remote monitoring would reduce travel time potentially enabling additional flow changes, as needed.
2. Automated flow control gates at headings with substantial upstream water level fluctuations; however, assuming water level control structures are installed, the flow control device could have little additional benefit.

Table 5 provides a description of the improvements proposed for each site, the objective of the improvements and estimated Level 1 and Level 2 improvement costs. For each site and level of improvements, upfront capital costs and annualized capital, operations, and maintenance costs are provided. All costs are subject to refinement as informed by more detailed review and design.

[6] "SCADA-Ready" describes a package of hardware and/or software that communicates and operates locally but has been specifically designed and installed to readily accept a data transmission and receiving device (e.g. radio, cellular modem, etc.) and to provide remote communication with an established base station and SCADA human machine interface (HMI).

Table 5. Site Improvement Matrix.

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
SCADA Office Base Station		Allows remote monitoring of measured parameters at SCADA equipped sites. Also allows remote control and adjustment of set points at automated water level or flow control sites. Provides for storage of data and interface for developing comprehensive status reports, usage statistics, and monitoring information for improved water management, accounting and reporting.	Level 1 Modernization and Enhancement does not include SCADA at sites; therefore, base station is not required.	$0	$0	Furnish and install one desktop personal computer, including: processor, monitor, keyboard, mouse, drivers, USB, RS232, Ethernet, communication ports, cables, adapters, modems, printer, operating system software and HMI software. Base station spread spectrum radio, mast, and antenna for communication with remote sites. Five hardened laptops and vehicle mounts for operator/in-field use. Vehicle-mounted radios and antennas for remote communications and monitoring of sites.	$138,063	$17,039
Spare Equipment		Minimize down time associated with simple equipment maintenance or malfunctions and/or procurement of site or system specific hardware.	Small inventory of site and system specific equipment that is critical for proper operation of improvements.	$23,692	$2,913	None	$0	$0
Phase 1 Modernization - Improvement of Primary Inflow Locations and Primary Operational Outflow Locations								
Western Canal Heading	Inflow	Provide WCWD managers and WCWD canal operators with accurate inflow to the Western Main for improved water allocation, accounting and general management. Enable frequent adjustments to respond to changes in downstream demand.	Construct control section d/s from heading gates and install ADVM. Perform velocity index calibration. Install digital display at canal bank. Site will be SCADA-Ready. Enter into negotiations with afterbay operators to increase the frequency of adjustments allowable.	$55,400	$5,300	Add communication hardware to measurement site and integrate with SCADA system to provide real-time monitoring of flow rate and water level	$5,900	$600
Butte Creek Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the Western Canal as feedback on heading operation, general lateral operation, and for improved District water accounting. Spillage records will help inform the modernization process. Spill at this site is expected to decline with modernization and automation of the Western Canal.	Install pressure transducer in new stilling well upstream of weir crest to measure head on weir. Perform calibration of weir, install solar power system, data logger and digital display of water level.	$1,543	$116		$13,678	$955
501 Main Drain Outflow to Butte Creek	Spill			$1,543	$116		$13,678	$955
1656I Spill	Spill			$6,905	$378		$7,400	$700
Pratt Lateral Return Flow (Fenn Drain)	Inflow		Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$19,900	$1,090		$5,900	$600
Phase 2 Modernization - Improvement of Main Canal (Western Canal) Primary Control Points								
535 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site has recently been improved. No Level 1 Improvements recommended.	$0	$0	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$0	$0
634 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace existing weir structure in Western Canal with combination water level control structure with locally automated overshot gate set to maintain upstream water level.	$1,267,317	$69,419		$7,400	$700
702 Check Structure	Water Level Control			$1,152,106	$63,109		$7,400	$700

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
Nelson Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site will be improved in January 2015 to include two automated Langemann Gates. No Level 1 Improvements recommended.	$0	$0	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$0	$0
Dry Creek Sidegates	Heading	Provide accurate, repeatable and consistent flow to supply deliveries downstream in Butte Creek.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
870 Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
875 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site has recently been improved. No Level 1 Improvements recommended.	$0	$0	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$0	$0
924 Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
1090 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace existing weir structure in Western Canal with combination water level control structure with locally automated overshot gate set to maintain upstream water level.	$806,474	$44,176	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$7,400	$700
1115 Check Structure	Water Level Control			$748,869	$41,021		$7,400	$700
1152 Check Structure	Water Level Control			$691,264	$37,865		$7,400	$700
Butte Creek Radial Gate	Water Level Control	Reconfigure structure to maintain upstream water level control and pass fluctuations down to the Back and Front Slide Gates.	Install upstream water level sensor, drive motor, gear box, gate actuator and controls and related components to provide locally automated upstream water level control.	$79,214	$4,339	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$7,400	$700
1190 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site has recently been improved. No Level 1 Improvements recommended.	$0	$0		$0	$0
599 Headgates (Private)	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the private ditch.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
690 Headgates (Private)	Heading		Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400		$11,800	$1,200
701 Headgates (Private)	Heading		Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
735 Headgates (Private)	Heading		Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
743 Headgates (Private)	Heading		Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
806 Headgates (Private)	Heading		Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
1052 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
1131 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
1184 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
1190 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
Phase 3 Modernization - Improvement of Lateral Primary Control Points and Spill Routing								
Highline Extension and Pratt Lateral Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards.	Replace four existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$212,400	$13,600	None	$0	$0
Back Slide Gates	Water Level Control	The function of this structure will remain the same as current, but will be reconstructed to increase operator safety, provide flexibility in the adjustment of upstream water level, and also minimize flow restriction during off-season/winter stream flows.	Retrofit gates with gear reduction boxes and hand cranks to simplify seasonal opening and closing and improve operator safety.	$28,600	$1,567	None	$5,900	$600

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
Front Slide Gates	Water Level Control	Structure function will be reoperated to maintain upstream water level in the 'Reservoir' and pass excesses down Little Butte Creek. A constant water level in the 'Reservoir' will provide more steady deliveries to the Main and Ward Canals. Winter operation of this site	Replace approximately one half of existing rectangular gates with locally automated radial gates set to maintain upstream water levels. Retrofit remaining rectangular undershot gates with gear reduction boxes and hand cranks to simplify seasonal opening and closing and improve	$710,500	$50,575	Install communication hardware and integrate gates with SCADA system to allow remote monitoring of water levels and gate function, and also remote manual adjustment of gate set points.	$7,400	$700
Ward Heading	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries. Improve operator safety during operation of the structure and increase abilities to provide flexible delivery service and respond to changes in downstream demand to minimize spillage.	Remove existing structure and construct new concrete heading structure with additional capacity. Install locally automated flow control gates to maintain a set flow downstream to supply deliveries.	$224,000	$16,000	Install communication hardware and integrate gates with SCADA system to allow remote monitoring of flow rate and gate function, and also remote manual adjustment of gate set points.	$7,400	$700
Main Heading	Heading			$268,800	$19,200		$7,400	$700
Main Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace nine existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries. Replace first 5 structures with combination structures with locally automated overshot gate.	$1,618,100	$119,100	None	$37,000	$3,500
1500 Ditch Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
1625 Ditch Headgates	Heading			$26,400	$2,400		$11,800	$1,200
Ward Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace eight existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries. Replace first 4 structures with combination structures with locally automated overshot gate.	$1,367,800	$100,200	None	$29,600	$2,800
W120 Headgate	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
924 Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace ten existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$531,000	$34,000	None	$0	$0
924L Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback loop on	Replace weir box with new. Install sharp crested weir plate and mount custom staff	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir.	$15,400	$1,500
924O Spill	Spill			$8,700	$700		$15,400	$1,500

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
HL115 Spill	Spill	heading operation, general lateral operation, and District water accounting.	gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500
Dry Creek at Harris Dam (RID joint site)	Flow Control	Increase control and measurement of flows diverted to serve Western Canal Water District that were delivered to Little Dry Creek u/s. Allow flows in excess of WCWD demand to stay in Little Dry Creek for possible delivery to downstream customers, including Secondary.	Replace three of the six flashboard bays with undershot gates to provide controlled deliveries to WCWD in the amount that they diverted into Little Dry Creek upstream. Remaining bays should be set for emergency spill. Add ADVM downstream for measurement. Increase the weir length in the Little Dry Creek structure to the south and have all excess flow pass over the top of the weir to maintain upstream level	$53,000	$4,526	Install water level sensor upstream of gates for monitoring purposes. Install communication hardware and integrate level sensor and ADVM with SCADA system to allow remote monitoring.	$6,785	$690
Little Dry Creek Dam	Spill	Provide accurate and accessible measurement of spillage to Little Dry Creek as feedback on heading operation, deliveries operations, and for improved District water accounting.	Install sharp crested weir plates and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116	Install pressure transducer in new stilling well upstream of weir crest to measure head on weir. Perform calibration of weir, install solar power system, data logger and digital display of water level. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$13,678	$955
Phase 4 Modernization - Improvement of Lateral Secondary Points, Sublateral Control Points and Secondary Spill Points								
1500 Ditch weirs	Water level control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace five existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$204,500	$13,000	None	$0	$0
1500L Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback loop on heading operation, general lateral operation, and District water accounting.	Replace weir box with new. Install sharp crested weir plate and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir. Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500
W120 Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace four existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$126,200	$8,000	None	$0	$0
W120GSpill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback loop on heading operation, general lateral operation, and District water accounting.	Replace weir box with new. Install sharp crested weir plate and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir. Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500
Pratt Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
Skinner Dam	Water Level Control	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the private ditch.	Construct stable and uniform cross section in existing canal cross section just downstream from diversion with Highline Extension and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900		$5,900	$600
P52 Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback on heading operation, general lateral operation, and District water accounting.	Replace weir box with new. Install sharp crested weir plate and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir. Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500

System Modernization Costs

The total combined cost (all phases, Level 1 and Level 2) of system modernization is estimated to be approximately $11,180,000, with annualized estimated costs of $743,000. Individual costs by modernization phase range from a low of $132,000 to a high of $5,404,000 for Phase I and Phase III, respectively. Costs are further summarized in Table 6. Additionally, the costs of a SCADA base station and mobile operator terminals that would form the backbone of the District SCADA system have been estimated, along with the cost of spare equipment to be kept on hand to repair or replace individual site components due to theft, vandalism, or other failure.

Table 6. Summary of Estimated Capital and Annualized Costs.

	Level 1		Level 2	
Modernization Phase	Capital Cost ($)	Annual Cost ($/yr)	Capital Cost ($)	Annual Cost ($/yr)
Phase I - Improvement of Primary Inflow Locations and Primary Operational Outflow Locations	$85,292	$6,999	$46,555	$3,809
Phase II - Improvement of Main Canal Primary Control Points	$5,009,230	$288,790	$166,800	$16,700
Phase III - Improvement of Lateral Primary Control Points and Spill Routing	$5,200,257	$372,522	$204,163	$19,445
Phase IV - Improvement of Lateral Secondary Points, Sublateral Control Points and Secondary Spill Points	$409,600	$28,900	$58,000	$5,700
Total Cost =	$10,704,379	$697,212	$475,518	$45,654
SCADA Office Base Station	-	-	$138,063	$17,039
Spare Parts	$23,692	$2,913		-

Potential Benefits

The proposed system modernization plan described herein represents comprehensive improvements to the district's distribution system, adding several automated control structures, improved measurement, new heading structures, re-regulation points, and SCADA. Flow paths targeted under the system modernization project are:

- Operational spillage,
- Deliveries to customers,
- Tailwater,
- Diversions, and
- Drainage outflows

Improvements would allow reduced operational spillage and reduced deliveries due to increased delivery efficiency, which would reduce on-farm tailwater and, in some cases, deep percolation. Reduced deliveries result in reduced diversions, which results in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and could potentially be available to meet unmet local demands or to meet regional or statewide objectives. Additionally, water quality benefits may occur through reduced tailwater outflow.

Through implementation of the complete system modernization program (Phases I - IV and Levels 1 and 2), it is estimated that approximately 20 to 50 percent[7] of existing operational spillage could be conserved annually, or between approximately 5,000 and 12,000 af per year.

From a local perspective, this conserved water could be used to increase local water supply reliability and to increase local delivery flexibility. From a regional or statewide perspective, water conserved that would not otherwise be used by downstream water users could be used to increase overall water supply or to meet in-stream flow and/or water quality objectives.

Each phase provides varying levels of anticipated potential benefits with the first two phases likely seeing greater benefit than the third and fourth due to the greater number of sites improved, establishment of primary spill routing, and improvement of control structures that are located higher in the system (i.e. have control over a larger proportion of the total water diverted). The estimated marginal range of percent reduction in spillage and boundary outflow achieved by completing phases is described below:

1. Phase I: 1 to 2 percent reduction; 240 to 480 af of targeted outflows
2. Phase II: 10 to 20 percent reduction; 2,400 af to 4,800 af of targeted outflows
3. Phase III: 8 to 25 percent reduction; 1,920 af to 6,000 af of targeted outflows
4. Phase IV: 1 to 3 percent reduction; 240 af to 720 af of targeted outflows

Net Benefit Analysis

The district is currently implementing associated EWMPs at locally cost-effective levels. WCWD has not used its full allocation in recent years, and thus would not achieve cost savings through additional conservation. The estimated implementation cost per unit of water conserved is presented in Table 7. As a result, further implementation of the system modernization project is not locally cost effective at this time. In the future, it is anticipated that the costs and estimated benefits of this improvement project will be evaluated as additional information becomes available.

[7] Based on estimated percent reductions in spillage for various improvement measured listed in the technical memorandum "Spillage Reduction- Monitoring and Verification" published by the Agricultural Water Management Council, local conditions, experience, and judgment. Limited reductions in tailwater may occur to some degree based on improved delivery steadiness, flow measurement, and control.

Table 7. Estimated Implementation Cost per Unit of Water Conserved.

Modernization Phase	Annual Cost, Levels 1 and 2 ($/yr)	Conserved Water Range (af/yr)			Conservation Cost ($/af)		
Phase I - Improvement of Primary Inflow Locations and Primary Operational Outflow Locations	$11,099	240	to	480	$23	to	$46
Phase II - Improvement of Main Canal Primary Control Points	$313,695	2,400	to	4,800	$65	to	$131
Phase III - Improvement of Lateral Primary Control Points and Spill Routing	$402,495	1,920	to	6,000	$67	to	$210
Phase IV - Improvement of Lateral Secondary Points, Sublateral Control Points and Secondary Spill Points	$35,529	240	to	720	$49	to	$148
Totals	$762,818	4,800	to	12,000	$64	to	$159

Project 2: Boundary Outflow and Primary Spill Measurement

Project Description

The objectives for the Boundary Outflow and Primary Spill Measurement project are described in Table 8.

Table 8. Objectives of Boundary Outflow and Primary Spill Measurement.

Objective	Boundary Flow and Primary Spill Measurement
Improve Water Use Efficiency	Measurement of operational spillage and drainage flows can be used to make better informed system adjustments that can lead to reduced spillage and possibly a reduction in total demands. Reduced spillage and reduced tailwater can lead to reduced diversions.
Develop Water Use Data	Measurement of boundary outflows and primary spillage provides the data necessary to quantify surface water leaving district, better define unmeasured flows (such as deep percolation), determine areas of high loss, characterize operational efficiencies, and aid in prioritization of improvements.
Support Reporting	Measurement of spillage, boundary flows and recovered drainwater provides information relating to water supply, water use, water quality, environmental benefits, etc. Measurement also supports the district in responding to potential inquiries from landowners regarding water supply, water use, and historical trends.
Increase Operational Efficiency	Measurement of spillage enable operators to make corresponding adjustments at lateral headings or at the diversion to reduce spillage or total diversions. Measurement provides early detection of end canal conditions (high or low) that may be impacting delivery service.

The project summaries provided in this attachment include an inventory of existing or potential sites that fall into one of the classifications described in Table 9.

Table 9. Descriptions of Site Type Classifications.

Site Type Classification	Description	Improvement Package
Boundary Inflow	Flows entering the district boundaries and providing the availability of increased supply.	Boundary Flow and Primary Spill Measurement
Boundary Outflow	Flows leaving the district boundaries and representing excess inflows, intentional releases to satisfy obligations to meet out-of-District demands, or water management issues.	Boundary Flow and Primary Spill Measurement
Internal Outflow	Flows intentionally discharged from district canals to drainage channels for downstream delivery or possible recapture (e.g. deliveries to Secondary).	Boundary Flow and Primary Spill Measurement
Internal Inflow	Additional supply entering the district from within its boundaries. (e.g. groundwater wells).	Boundary Flow and Primary Spill Measurement
Internal Spill	Excesses in supply canals that are discharged to drain channels through safety spill structures.	Boundary Flow and Primary Spill Measurement

For each selected site, conceptual designs were developed that improve the site to meet the objectives. A total of two boundary outflow locations, two internal spill/outflow sites, and one drainwater recovery site were identified for improvement under this improvement package. The selected sites (shown in Figure 2) were identified as high priority through consultation with District personnel or identified has likely high use sites based on their position in the distribution system, such as at the end of main canals or primary laterals. Several additional spill sites were identified but not included in this improvement package because of their perceived low volume or infrequent use. Recommended improvement sites are subject to revision following more detailed review and analysis.

Recommended measurement devices for the boundary and spill flows vary by site type, site conditions and existing infrastructure or proposed infrastructure. Additionally, the intensity of use (rate and duration) relative to other sites, and the importance of the site to meeting the objectives also factor into the selection of measurement devices. In total, four measurement strategies were developed based on unique conditions. In general, it is recommended that improvement projects or phased modernization employ the same device, or a limited selection of devices, throughout the District to maintain consistency in reporting, accuracy, and operations. This also simplifies training of new employees, maintenance protocols, and troubleshooting, as well as minimizes the required spare parts. The four measurement strategies are described in Table 10.

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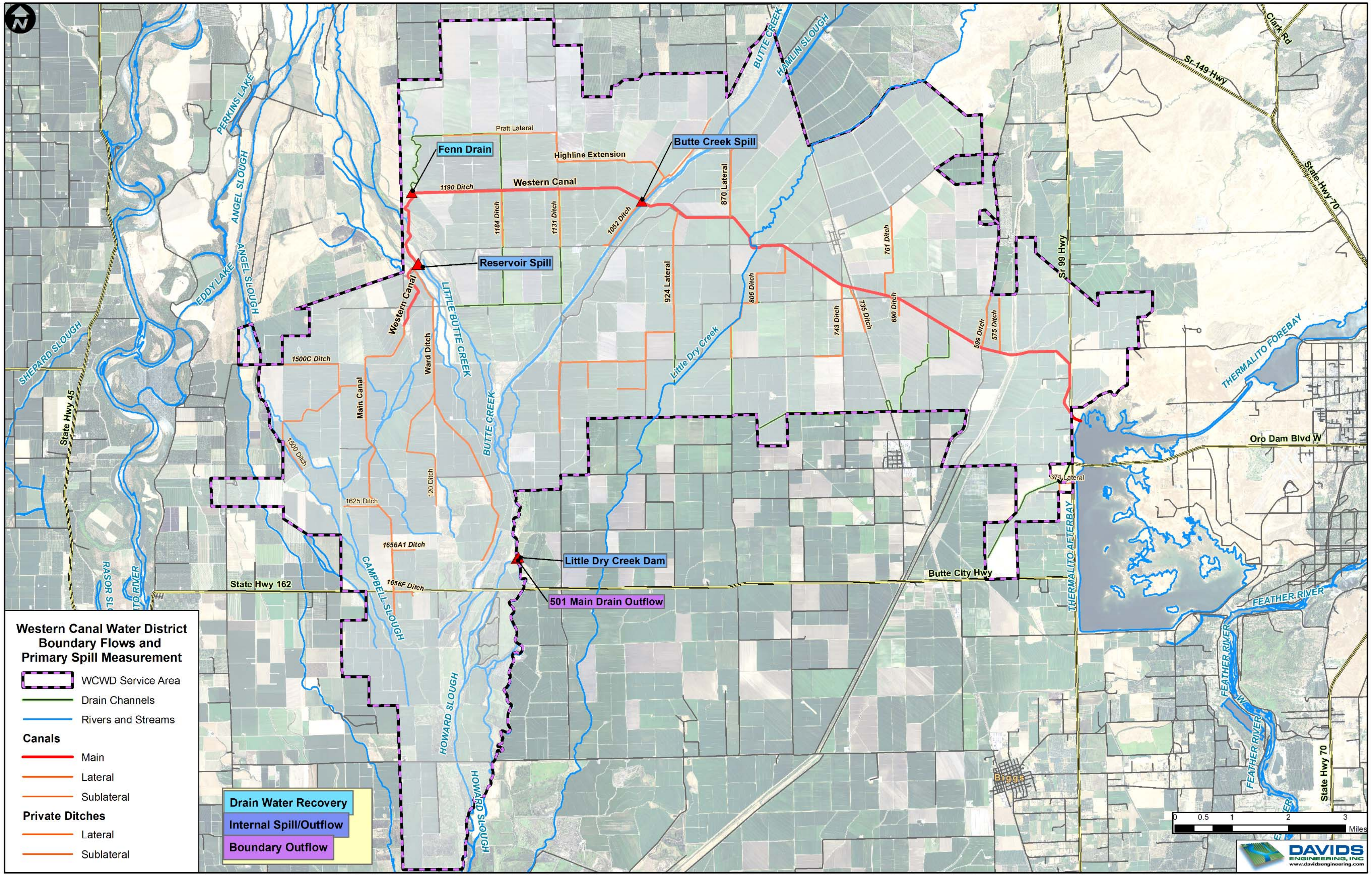

Figure 2. WCWD Boundary Outflow and Primary Spill Sites.

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Table 10. Descriptions of Measurement Devices and Associated Advantages and Limitations.

Measurement Device	Measurement Method	Advantages	Limitations
Acoustic Doppler Meter	Doppler technology measures water velocity. Velocity x Area = Flow rate	High accuracy depending on siting. Generally little calibration and are SCADA-Ready. No moving parts.	Requires power source. Requires a stable cross section and uniform flow velocities. Weeds or other obstructions impact accuracy.
Propeller Meter	Flow through pipe rotates propeller. Rotational velocity is related to water velocity. Velocity x Area = Flow rate	Simple and relatively inexpensive device. Can provide good accuracy depending on siting. Effective in submerged situations. District staff is familiar with technology.	Air pockets, turbulence, weeds or other trash may cause inaccuracies. Moving parts require maintenance. Requires full pipe.
Sharp Crested Weir	For a given weir length, flow is determined by depth of flow over weir crest.	Simple and inexpensive device. Easily adaptable to majority of existing spill structures. Good accuracy depending on siting. Minimal maintenance required.	Requires free fall of flow over weir and uniform velocities.

Measurement of drain channels often presents unique challenges not often experienced in distribution canals. These include, but are not limited to: potentially unstable cross sections with heavy vegetative growth, widely fluctuating flows including storm water runoff, are not typically maintained, higher than normal trash loads, below grade, low hydraulic gradients, and may be subject to additional environmental regulations.

Several of the boundary flow and spill sites are also incorporated in the modernization package as measurement of outflows is an important component of water management.

In most cases, selected spill sites are existing sites that require only minimal improvement or slight reconfiguration; however, some require complete reconstruction or new measurement method. Boundary outflow and internal outflow sites are generally new sites, but their locations are defined at the crossing of the District boundary by the conveyance channel. These sites may require the modification of the site for flow measurement accuracy or installation of the measurement device.

Inventory of Existing Sites

Existing sites were identified through consultation with District operations staff and digitally inventoried in tabular form and in an interactive mapping format. For each site type, several sites were selected for field inspection to obtain dimensions, coordinates, photos and operational features typical of the site type to aid in strategy development and costing. For each site proposed for improvement, Table 11 provides the site name, the site type, latitude, longitude, and a description of the existing conditions. As previously discussed, the improvement process described here focuses on primary outflow and spill points and drain water recovery sites and may not include all minor features.

Table 11. Inventory of Existing Sites.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
501 Main Drain Outflow to Butte Creek	Boundary Outflow	39.472	-121.872	Structure holds water level for upstream deliveries. Concrete abutments with several manually adjusted flashboard bays. Steel catwalk spans structure. Approximately 4ft of drop through structure.
Butte Creek Spill	Internal Spill/ Outflow	39.563	-121.830	Concrete overpour structure spills water as levels rise above crest. Designed to pass 200 cfs. Two undershot gates used for delivery to Butte Sink during Fall. Manual measurement of spill three times per day.
Little Dry Creek Dam	Boundary Outflow	39.472	-121.871	Provide accurate and accessible measurement of spillage flow rate from Little Dry Creek as feedback on heading operation, deliveries operations, and for improved District water accounting.
Pratt Lateral Return Flow (Fenn Drain)	Drain Water Return	39.566	-121.905	Return flows to the Western Canal from Pratt Lateral spill and Fenn deliveries. Meandering earthen cross section of various widths. Culvert road crossing just upstream from return flow to Western Canal.
Reservoir Spill	Internal Spill/ Outflow	39.547	-121.903	Flows bypassing back slide gates and continuing downstream in Little Butte Creek. Natural, earthen channel.

Boundary Outflow and Primary Spill Measurement Improvements

For each site, improvement is split into two levels, Level 1 and Level 2. Level 1 improvements often are infrastructure and measurement enhancements that are manually operated or read, but designed as SCADA-Ready[8] sites. Level 2 improvements build on the Level 1 improvements by adding electronic sensors, installing on-site digital display of flow rate or other parameters, or add remote monitoring or control through a Supervisory Control and Data Acquisition System (SCADA). Level 1 improvements are stand-alone, while Level 2 improvements generally require Level 1 to be completed prior or simultaneously. This phased implementation provides the District the flexibility to complete Level 1 (which has significant benefits on its own) while assessing the benefits of SCADA,

Little Dry Creek Dam Outflow to Butte Creek.

[8] "SCADA-Ready" describes a package of hardware and/or software that communicates and operates locally but has been specifically designed and installed to readily accept a data transmission and receiving device (e.g. radio, cellular modem, etc.) and to provide remote communication with an established base station and SCADA human machine interface (HMI).

prioritizing sites, establishing the SCADA base station and gradually implement the more complex or more expensive sites.

Although Level 2 is not universally required to be completed to obtain significant benefits, several sites will greatly benefit from it. For example, remotely located end spill sites or boundary outflow sites are not frequently visited by operators, and if they are visited and spill is noticed, it may not be worth the travel time to the heading to make a change. Remote monitoring would eliminate travel time, but does require the development of a SCADA office base station.

Additionally, in some cases, there is potentially some savings in capital costs by completing level 1 and level 2 at the same time.

Table 12 provides a description of the improvement proposed for each Boundary Flow and Primary Spill sites, the objective of the improvement and a Level 1 and Level 2 cost. All costs are subject to revision following refinement of site improvements following more detailed review and design.

Table 12. Summary of Boundary Outflow and Primary Spill Measurement Improvement Sites.

Site Name	Site Type	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
501 Main Drain Outflow to Butte Creek	Boundary Outflow	Install sharp crested weir plates and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116	Install and configure pressure transducer, PLC, solar power site, communication hardware, and digital flow display. Integrate with SCADA system to allow remote monitoring.	$13,678	$955
Butte Creek Spill	Internal Spill	Cut-down top of existing concrete spill wall and install sharp crested weir plates. Mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116		$13,678	$955
Little Dry Creek Dam	Internal Spill	Install sharp crested weir plates and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116		$13,678	$955
Pratt Lateral Return Flow (Fenn Drain)	Drain Water Return	Install and configure ADVM in existing channel in culvert pipe. Construct solar power site and add digital flow display. Site will be SCADA-ready.	$19,900	$1,090	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$5,900	$600
Reservoir Spill	Internal Spill	Install and configure ADVM in existing channel in stable cross section. Perform velocity index calibration. Construct solar power site and add digital flow display. Site will be SCADA-ready.	$21,293	$1,166	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$5,900	$600

Boundary Outflow and Primary Spill Measurement Costs

Reconnaissance level cost estimates were prepared for the improvement package described in the preceding sections as a basis for prioritization and funding of site improvements. The total combined cost (Level 1 and Level 2) of improvement is approximately $99,000, with annual costs of $7,000. Total costs are further summarized in Table 13.

Table 13. Summary of Costs.

	Level 1		Level 2	
Boundary Flow and Primary Spill Measurement	**Capital Costs ($)**	**Annual Costs ($)**	**Capital Costs ($)**	**Annual Costs ($)**
Boundary Flows Subtotal	$1,543	$116	$13,678	$955
Internal Spills and Return Flows Subtotal	$44,280	$2,487	$39,155	$3,109
Total Cost =	$45,823	$2,603	$52,833	$4,064

The aforementioned costs do not include a SCADA base station (which would be required for Level 2), mobile operator terminals that would form the backbone of the District SCADA system, or costs of spare equipment to be kept on hand to repair or replace individual site components due to theft, vandalism, or other failure. These costs are summarized in Table 14. This cost represents a robust SCADA network that would be capable of monitoring the identified measurement and drain recovery sites as well as existing or future sites, such as detailed in Project 1: System Modernization.

Table 14. Summary of Costs for SCADA Office Base Station and Spare Parts.

Item	Capital Cost ($)	Annual Cost ($)
SCADA Office Base Station	$138,063	$17,039
Spare Parts	$23,692	$2,913

Potential Benefits

Flow paths targeted under the boundary flow and primary spill measurement package are:

- Operational Spillage
- Tailwater
- Drainage Outflows
- Diversions

Measurement of boundary flows and spills would provide operators tools to support reduction of operational losses. Reduction in losses may result in decreased required diversions. Available water not diverted remains in storage and could potentially be available to meet unmet local demands or to meet regional or statewide objectives.

Through implementation of this package, it is estimated that approximately 3 to 10 percent[9] of existing spills could be conserved annually, or between approximately 720 and 2,400 af per year depending on the level of implementation.

Net Benefit Analysis

The district is currently implementing associated EWMPs at locally cost-effective levels. WCWD has not used its full allocation in recent years, and thus would not achieve cost savings through additional conservation. The estimated implementation cost per unit of water conserved ranges from approximately $11 to $37 per acre-foot. As a result, further implementation of the boundary outflow and primary spill measurement project is not locally cost effective at this time. In the future, it is anticipated that the costs and estimated benefits of this improvement project will be evaluated as additional information becomes available.

[9] Based on estimated percent reductions in spillage for various improvement measured listed in the technical memorandum "Spillage Reduction- Monitoring and Verification" published by the Agricultural Water Management Council, local conditions, experience, and judgment.

Project 3: Reservoir Bypass

Project Description

The reservoir is an intentionally impounded section of Little Butte Creek that accepts inflows from the east via the Western Canal and allows for delivery on the west side to the Main and Ward Laterals. This site poses several challenges, including:

1. Operation of the Front and Back slide gates to impound the Creek and provide conveyance through pond storage is a manual process that requires adjustment of 59 individual 5ft x 5ft metal gates. Gates must all be raised following the irrigation season to accommodate storm flows.
2. The relatively flat topography requires a significant incoming volume to increase water depth and increase conveyance capacity.
3. Normal upgradient stream inflows from can cause unexpected fluctuations that transfer to the Main and Ward laterals.
4. No measurement is installed at the Main and Ward Canal gate headings requiring significant judgment by operators.

As an alternative to the current configuration, WCWD has long considered the construction of a bypass canal that would be constructed along the eastern edge of the Creek and extend the Western Canal parallel to the Creek until approximately the location of the Front and Back Slide Gates. At this point, three individual siphons would carry the flow under the Creek to provide unrestricted flow to supply the Main and Ward Canals. To facilitate cost estimation of this alternatives, a conceptual design was developed making the following assumptions:

1. The bypass canal would follow an alignment as identified by WCWD staff as shown in Figure 3.
2. The total length of newly constructed canal would be approximately 6,300 LF with an additional 1,200 LF of inverted siphons. Siphons would range in length from 200 LF to almost 700 LF.
3. Design capacity was estimated at 500 cfs.
4. Limited ground slope (approximately 0.00013 ft/ft) is estimated to exist along the proposed alignment.
5. A trapezoidal canal with a top width of approximately 60 ft was assumed, and two parallel 60" diameter pipes were assumed for each siphon.
6. Siphons would be installed using bore and jack methods to minimize impacts to the Creek.
7. The canal would be unlined and embankments constructed of compacted earth fill sourced from excavation. It was assumed cut and fill quantities would approximately balance requiring no import.
8. Estimated costs do not account for the removal of the Front and Back Slide Gates. An environmental impact/benefit analysis should be completed to evaluate the environmental impact that removal might pose, as opposed to simply removing the gate panels and abandoning the structure.

Figure 3. Overview of Existing Canal Alignment (Red) and Conceptual Alignment (Blue) of Reservoir Bypass Canal.

Reservoir Bypass Costs

Reconnaissance level cost estimates were prepared the improvement project described in the preceding sections as a basis for prioritization and funding of site improvements. The total combined cost of improvement is approximately $12,815,000 with estimated annualized costs of $758,000.

Potential Benefits

The construction of a reservoir bypass canal and related components has no water conservation benefits that could be reasonably quantified at this stage of design. However, several qualitative benefits to WCWD include:

- Reduction of labor requirements associated with operations of the reservoir. The alternative provides a direct supply to the Main and Ward Laterals and may improve the operational efficiency of these sites.
- Increased capacity to meet downstream irrigation demand (limited to downstream canal capacity constraints) may enable increased rotational frequency or larger available irrigation heads. This may increase irrigation efficiency.
- Reduced potential for environmental impacts associated with impounding water. An appropriate environmental review would be required for this project.
- Feather River water and Little Butte Creek flows no longer required to be comingled.
- Potential for reduced spillage due to additional control over inflows.
- Increased safety due to elimination of the Front and Back Slide Gates.

Net Benefit Analysis

A net benefit analysis was not performed for this project because the improvements are not aligned with specific EWMPs.

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7.10.5 Drought Management Plan

Introduction

On April 1, 2015 Governor Brown issued Executive Order B-29-15, mandating agricultural water suppliers to include in their 2015 Agricultural Water Management Plan (AWMP) update a detailed Drought Management Plan (DMP) describing actions and measures taken to manage water demand during drought. Three years later Assembly Bill 1668 (AB 1668) was passed on May 31, 2018. AB 1668 amended the California Water Code (CWC) and requirements for AWMPs, providing more detail on the specific requirements for a Drought Plan, or DMP (CWC 10826.2). This DMP builds upon WCWD's existing shortage allocation policies, which were the foundation of the 2015 DMP. The 2020 DMP includes the components required by CWC 10826.2 and recommended by DWR in its 2020 AWMP Guidebook for inclusion (DWR 2020). Additionally, the 2020 DMP provides a reflection on and evaluation of the 2012-2016 drought.

WCWD is well-positioned to respond to drought conditions, with access to a number of reliable water supplies. Since its formation in December 1984, WCWD has had a full surface water supply in all but three years (1991, 1992, and 2015). WCWD holds a surface water right of 145,000 af from storage on the North Fork of the Feather River that is not subject to reduction, a surface water supply of 150,000 af that is available in most years according to its 1986 agreement with the State, and adjudicated water rights on Butte Creek that are subject to surplus availability and dependent on hydrologic conditions. During years in which curtailment is allowed under the agreement, WCWD's water supply of 150,000 af from the State can be reduced by up to 50 percent, as discussed in greater detail below. For purposes of this DMP, drought years are generally considered to be years of reduced surface water supply due to curtailment.

The following sections describe WCWD's (1) drought resiliency planning actions undertaken to prepare for drought, and (2) drought response actions undertaken to manage available water supplies and to meet customer demands to the maximum extent possible during a drought.

Drought Resilience Planning (§10826.2(a))

This section describes actions and activities undertaken by WCWD to prepare for drought and effectively manage and mitigate the effects of surface water shortage. It includes the determination of water supply availability and drought severity, identification and analyses of potential vulnerability to drought, and opportunities and constraints for improving drought resiliency planning.

<u>Determination of Water Supply Availability and Drought Severity (§10826.2(a)(1))</u>

As described above, WCWD has access to several surface water supply sources that are available in all, or most, years.

WCWD holds a pre-1914 surface water right for diversion of up to 145,000 af of upstream stored water on the North Fork of the Feather River. This right is not subject to reduction.

WCWD also holds a pre-1914 water right for diversion of up to 150,000 af of natural flow from the Feather River, subject to reduction during drought under terms of its 1986 diversion agreement with the State. As stipulated in its agreement with the State, WCWD's water supply depends on the Lake Oroville inflow. WCWD's surface water supply can be reduced under the following conditions:

- DWR forecast April to July unimpaired runoff into Lake Oroville is less than 600,000 af[12], or
- Total current year predicted and prior year actual deficiencies in unimpaired runoff (as compared to 2,500,000 af) exceed 400,000 af for one or more successive prior water years with less than 2,500,000 af of runoff.

When a reduction is allowed, the WCWD allotment can be reduced by up to 50 percent in any one year, but not by more than 100 percent in any seven consecutive years. Additionally, reductions in any given year cannot exceed the percent reduction experienced for agricultural use by State Water Project (SWP) contractors.

In addition to these supplies, WCWD also has adjudicated water rights on Butte Creek that are subject to surplus availability and are dependent on hydrologic conditions. While the maximum diversion is 9,300 af, average annual diversions have been approximately 7,800 af in recent years. WCWD monitors hydrologic conditions to assess the availability of these supplies from year to year.

<u>Potential Vulnerability to Drought (§10826.2(a)(2))</u>

Generally, WCWD water supplies have been sufficient in all but the driest of years. As described above, under the 1986 agreement with the State WCWD's allotment of natural flow from the Feather River can be reduced by up to 50 percent in any one year, but not by more than 100 percent in any seven consecutive years. This reduces the District's vulnerability to ongoing surface water supply curtailment across consecutive years of drought.

The relative security of these supplies and WCWD's other pre-1914 and adjudicated water rights, even during historic drought conditions, suggests that the District is well-protected against drought vulnerability.

<u>Drought Resilience Opportunities and Constraints: Availability of New Technology or Information (§10826.2(a)(3)(A))</u>

In recent years, WCWD has made substantial improvements to both distribution system infrastructure and operational practices that have improved overall distribution system water management and increased operational efficiency. During periods of surface water shortage, WCWD takes additional, extraordinary measures to further increase operational efficiency and to maximize the beneficial use of available water supplies. Highlights of WCWD activities to increase operational efficiency include the following:

[12] The final, official forecast must be made by April 10 of each year.

- Automation of three primary control structures along the Western Main Canal and automation of the Nelson Check during winter 2015-2016 to reduce spillage, increase operational efficiency, and conserve available water supplies.
- Adoption of the Feather River Regional Agricultural Water Management Plan (FRRAWMP), which included the identification of approximately $12 million in modernization and boundary flow measurement improvements and $13 million in potential improvements to the main canal to bypass Little Butte Creek. These projects have the potential to significantly increase operational efficiency. It is anticipated that these improvements will be implemented over time subject to funding and project prioritization.
- Implementation of a comprehensive water information system (WIS) in 2015 that improves overall system management and incorporates tools for operational staff to support increased operational efficiency (e.g. transitioning from a paper-based tracking system to a digital database system, greatly increasing staff efficiency). The WIS also increases the flexibility with which customers can manage available water supplies, particularly during drought years.
- Operation of the FLOW Portal, an online platform that gives growers access to their delivery flow measurements in real-time in an effort to reduce farm tailwater.
- Increased coordination among operators and with customers to reduce surface outflows resulting from operational spillage and tailwater. These improvements are achieved through a combination of more frequent spill monitoring and more frequent flow adjustments in the system in response to grower demands.
- Submittal of grant applications to the USBR in the summer of 2020 that would fund projects to measure primary boundary outflow sites, providing staff with real-time estimates of water leaving the District. If successfully funded, it is anticipated this work will be completed between 2021-2022.

WCWD plans to continue implementing new technologies to improve drought resiliency and operational efficiency, and is continually exploring new technologies and information to achieve these ends.

<u>Drought Resilience Opportunities and Constraints: Availability of Additional Water Supplies (§10826.2(a)(3)(B))</u>

WCWD's surface water supplies have been generally sufficient during years with a full surface water supply. In years of surface water shortage, growers within WCWD are able to utilize groundwater to augment available water supplies. These groundwater supplies are supported by surface water recharge in years when surface water supplies are sufficient. The conjunctive management of surface water and groundwater supplies over time is a key component of WCWD's drought management strategy.

The District does not own or operate any groundwater wells, although it allows growers to optimize the use of available groundwater during drought through provisions in its shortage allocation policies. These provisions allow growers to convey groundwater pumped using private wells through the District conveyance system, subject to District approval, enhancing the beneficial use of groundwater supplies.

Growers additionally augment water supplies in drought years through the assignment (internal transfer) of water among growers, which is allowed by WCWD. Also, growers increase drainwater recycling by PTO-driven pumps or other means.

Drought Resilience Opportunities and Constraints: Other Planned Actions (§10826.2(a)(3)(C))
The District is actively involved in coordinating and collaborating with adjacent agricultural and urban water suppliers and Groundwater Sustainability Agencies. The Agency is willing to continue supporting conjunctive management to the extent overdraft, land subsidence, and other undesirable results are avoided. Additionally, the District is actively involved in discussions with the State regarding meeting unimpaired flow requirements through voluntary agreements (VA). VAs may require the District to implement certain conservation measures, including land fallowing, to increase in-stream flows during endangered anadromous fish runs.

Drought Response Planning (§10826.2(b))
This section describes actions and activities undertaken by WCWD to address surface water shortage. It includes discussion of the policies and process for declaring a water shortage and implementing water shortage allocation, methods and procedures for the enforcement or appeal of triggered shortage responses, methods and procedures for monitoring and evaluating the drought management plan, communication protocols and procedures, potential financial impacts of drought, and proposed measures to overcome those impacts.

Policies and Processes for Water Shortage Declaration and Water Shortage Allocation and Implementation (§10826.2(b)(1))

Historically during drought, WCWD has apportioned available surface water supplies on a pro-rata basis to irrigable acres for which water applications are received, and informed landowners of the total acre-feet available for irrigation between April 1 and October 31. The total volume of water delivered and remaining for each landowner is then tracked over the course of the irrigation season.

Current shortage policies (Attachment A) include the following, many of which are presented here verbatim:

- When surface water supplies are reduced due to curtailment by the State or other factors as otherwise determined by the Board of Directors, available surface water is allocated on a pro-rata basis to all primary acreage for which a standby fee is paid. Secondary acreage receives no allocation, except as assigned from eligible primary acres.
- An initial allocation will be made by the Board considering system losses and other obligations based on the preliminary DWR forecast as provided on or before February 15. The initial allocation may be revised based on applications for water received, revisions to the forecast, or other factors.
- The initial allocation will be made on March 15 with applications for water due by April 15. No allocation will be made for lands for which applications are not timely received, except upon direction of the Board.

- After receipt of applications, the District will mail out a final water allocation, invoices, and issue notice of rules, rates and policies regarding drought conditions.

The following additional conditions apply:

1. Surface Water
    a. The District will deliver water only to Applicants who have timely and completely filled out an application.
    b. The District reserves the right to increase or decrease the final allocation at any time based on new information or changed circumstances. The District will notify all Applicants concerning any amendments to their allocation.
    c. The District will not supply water in excess of an Applicant's allocation. During the irrigation season, the District will keep track of Applicants' water use and will periodically notify each Applicant of then-current usage and remaining allocation. Failure of the District to provide notice shall not permit Applicant to divert water in excess of their allocation; each Applicant is expected to monitor their diversions to ensure they do not exceed their allocation. The District will cease deliveries once an Applicant's allocation has been delivered.
    d. Assignments of Surface Water
        i. Upon notice to the District, any Applicant may assign all or a portion of their surface water allocation to different fields within the District that are owned or leased by the same Applicant.
        ii. Applicants may assign all or a portion of their surface water allocation to another landowner/grower within the District, provided:
            1. The Applicant and the assignee complete a District assignment form and pay for the water in advance, including a one-time administration/wheeling charge of $200.
            2. Completed assignment forms may be approved by the General Manager at any time. If the General Manager denies a request for assignment or, due to unique circumstances, is unwilling to approve or deny the request, the assigning landowner may seek reconsideration by the Board of Directors. Requests for reconsideration must be received by the District office on or before the Wednesday before the District's regular board meeting (the third Tuesday of each month) so the item may be placed on the agenda for consideration by the Board of Directors.
            3. The District reserves the right to deny assignment requests for any reason, including without limitation inadequate capacity to wheel the water through the District's facilities.
2. Groundwater
    a. The District will not allow the use of its facilities to wheel or accommodate the transfer or assignment of groundwater that may be pumped by landowners. Upon application, a landowner may be allowed to utilize District facilities to convey groundwater to the same landowner's fields. The District reserves the right to grant or deny such request for any reason.

3. Out of District Assignments
    a. Upon request, the Board of Directors of the District will consider assignments of any Applicant's surface water allocation to any Joint District. Prior to making the request, the Applicant must first have obtained the written consent of the applicable Joint District to the possible assignment. Notwithstanding the consent of the applicable Joint District, the District reserves the right to grant or deny any out of district assignment for any reason.
    b. The District will not permit out of District assignments to entities or individuals outside the Joint Districts.

To provide additional flexibility to customers in the use of available surface water supplies, current WCWD policy allows for the assignment of allocations/apportionments among landowners (Attachment B). Under this policy, any landowner may assign a portion of his/her allocation to another landowner in the District, subject to District approval. An administrative fee payable to the District of $200 applies. This policy provides substantial additional flexibility to landowners in maximizing the beneficial use of water within the District during periods of shortage.

<u>Methods and Procedures for Water Shortage Response Actions (§10826.2(b)(2))</u>
During periods of curtailment, the District's Board of Directors determines the course of action to manage available water supplies, including reiteration of the District's current shortage allocation and drought management policies and any revisions that may be required to best serve the landowners. District policies combine measures to reduce operational spillage and to equitably distribute available surface water supplies. Additionally, District policies allow for the conveyance of privately pumped groundwater via the distribution system to meet irrigation demands, subject to approval. These strategies enhance operational efficiency, delivery flexibility, and conjunctive use to maximize the use of available surface water and groundwater supplies to reduce shortage impacts, meet irrigation demands, and maximize the beneficial use of water within WCWD.

WCWD's water shortage response actions are enforced as described in the District's policies or other drought-related materials developed and disseminated by WCWD and the Board of Directors. Failure to comply will typically result in a fine and warning for the first violation; a second violation will typically result in an additional fine and loss of water delivery for the remainder of the irrigation season. Appeals of enforcement actions or for exemption from enforcement are accepted and will be considered by WCWD and the Board of Directors on a case-by-case basis.

<u>Monitoring and Evaluation of Drought Plan (§10826.2(b)(3))</u>
While a portion of the District's water supply is dictated by the 1986 agreement with the State, monitoring of hydrologic conditions to assess available water supply is important to WCWD's water management across the full range of hydrologic conditions experienced. To inform District decisions related to available water supply and to inform growers of supply conditions, the District actively monitors water supply information reported by the Department of Water Resources (DWR), the National Oceanic and Atmospheric Administration (NOAA), and others for Lake Oroville and the Feather River watershed as a whole. Information monitored includes storm activity, accumulated precipitation and snow, water year indices, reservoir storage and releases, and projected and actual reservoir inflow. This valuable information supports the District and its

customers in planning for water management and in making cropping decisions in all years. The value of monitoring a broad range of hydrologic information is amplified in years of drought but is also important during wet years due to flood risk in some areas of the District.

In years of curtailment, the District tracks grower applied water using the RemoteTracker delivery measurement system. This allows the District and individual growers to compare applied water estimates to their allotment to ensure the District is on track to reduce surface water diversions.

Communication Protocols and Procedures (§10826.2(b)(4))

WCWD encourages efficient on-farm water management to control demand on an ongoing basis. Because water rates are based on the volume of water delivered, WCWD's water charges implicitly encourage efficient on-farm water use. During curtailment years, on-farm water management efforts are enhanced through several extraordinary actions, which may include the following:

- Additional education and outreach
- Allocation of available water supplies
- Provision of water delivery information in near real time
- Enhanced enforcement of rules and regulations
- Coordination and collaboration with regional and statewide entities

These actions are summarized in the remainder of this section.

Outreach and Incentives

During periods of reduced supply, WCWD increases outreach efforts to encourage on-farm water conservation and to keep growers informed of hydrologic conditions and any changes to WCWD policies and practices to manage limited water supplies.

Allocation of Available Supplies

Under reduced surface water supply conditions, available water is allocated on a pro-rata basis to irrigable acres for which applications are received, as discussed previously. WCWD informs landowners of the total acre-feet available for irrigation between April 1 and October 31. The total volume of water delivered and remaining for each landowner is then tracked over the course of the irrigation season. In the curtailment year of 2015, the implementation of a water information system (WIS) by WCWD allowed the district to transition from a paper-based tracking system to apportion available surface water supplies to a digital database system, greatly increasing the efficiency with which apportionments are managed by staff. The District's policy of apportioning available water by landowner rather than by delivery point or field provides growers substantial flexibility, allowing field-specific planting and irrigation decisions to maximize the beneficial use of available district surface water and private groundwater supplies.

As described previously, WCWD allows the conveyance of privately pumped groundwater via the distribution system to meet irrigation demands, subject to approval. For privately pumped groundwater conveyed through the distribution system, the following steps are taken to ensure equitable distribution of water supplies:

- Flow meters are required on groundwater pumps discharging to the distribution system,
- The amount of groundwater pumped into the system (minus an assumed carriage loss) is added to the landowner's volumetric allocation, and
- Flow meters are monitored regularly over the course of the irrigation season to monitor and record pumped volumes.

Provision of Water Delivery Information in Near Real Time

Over the course of the irrigation season, water delivery information for each grower (including the remaining allocation) is available through District staff. An online interface has additionally been developed and implemented. The interface provides detailed information in near real time describing the timing and amount of water delivered by turnout and by field. This allows growers to access the information at their convenience and easily stay up-to-date on water deliveries and remaining available water.

Enhanced Enforcement of Rules and Regulations

WCWD's Irrigation Rules (AWMP Attachment 7.10.1) allow for the refusal of delivery by the District for wasteful use of water, whether willful, careless, or negligent. Irrigators who waste water may be refused WCWD water until the cause of the condition is remedied at the discretion of the General Manager. During periods of water supply shortage, WCWD may increase enforcement of rules related to the unauthorized use of water and tailwater runoff.

Coordination and Collaboration with Regional and Statewide Entities

WCWD coordinates and collaborates extensively with others regarding local and regional water management in all years. These activities intensify during periods of drought in order to minimize adverse impacts across a range of stakeholders. Examples of longstanding and recent collaboration and coordination activities include the following:

- Bi-weekly coordination calls with the Joint Districts, other Feather River diverters, and the State with regard to Feather River water supplies and demands;
- Reporting of information to the California Department of Water Resources and other governmental entities;
- Participation on the Northern Sacramento Valley Integrated Water Management Plan (NSVIRWMP) board;
- Participation in NCWA's Drought Strike Team;
- Presentations and active social media and other outreach to interested parties including lenders, legislative staff, media representatives, government agency staff, and others regarding surface water and groundwater management, food production and agriculture, and fish restoration and other habitat efforts.

Additionally, WCWD staff serve as members of the water advisory committees for Butte County and Glenn County. These committees address issues including overall water management, surface water and groundwater resources, and public education and outreach. WCWD also works in coordination with Butte County, Glenn County, and DWR to monitor and report groundwater levels within its service area and is actively implementing the Sustainable Groundwater Management Act of 2014 (SGMA).

Potential Financial Impacts of Drought and Proposed District Management Measures (§10826.2(b)(5))

The District's water charges use a volumetric rate dependent on the quantity of water delivered, with a required minimum charge. As a result, revenues are reduced in curtailment years due to reductions in available water for delivery. Revenues also decrease in curtailment years as a result of decreased water sales through out-of-district agreements and water transfers.

In addition to reduced revenues during curtailment years, operating costs increase substantially due to several factors. Increased expenditures include the following:

- Increased staff effort to provide direct customer service;
- Increased outreach to District customers, the general public, and other interested parties; and
- Increased reliance on outside legal and technical support to enhance service and to address reservoir operations, water rights, and other issues.

The District maintains appropriate reserves to cover the cost incurred during drought years, updating water rates in accordance with Proposition 218 to maintain adequate reserve funds, as necessary.

Evaluation of 2012-2016 Drought

The following sections describe the impacts of the 2012-2016 drought on water supply and water demand in WCWD.

As described previously, WCWD has historically experienced very reliable surface water supplies. During the 2012-2016 drought, WCWD had a full surface water supply of 295,000 acre-feet in all years except 2015. To illustrate actions by WCWD and its customers to manage available water supplies during drought years, the water supplies and water demands in 2015 are summarized and compared to other recent years with full supply (1999-2019, excluding 2015). All volumes summarized in this section are from the District water balance, described in Section 7.7 of the AWMP update.

This discussion also examines the effectiveness of WCWD's past drought resilience and drought response efforts, identifies lessons learned from the drought, and provides context for planning future actions.

Impacts on Water Supplies

To illustrate actions by WCWD and its customers to manage available water supplies during drought, water supplies for 2015 are summarized and compared to other years covered in the WCWD water balance (1999-2019, excluding 2015). The years 1999-2019, excluding 2015, represent years where the full surface water supply was available for diversion by WCWD. The year 2015 represents a year in which the 150,000 af water supply based on Feather River natural flow was curtailed by 50%, representing an overall reduction of approximately 25% of WCWD's surface water supply.

Average monthly Feather River diversions to WCWD are shown in Figure 7-11. Total average diversions between April and October were approximately 255,000 af in full supply years (1999-2019, excluding 2015), and 212,000 af in 2015.

Average monthly groundwater pumping within WCWD is shown in Figure 7-12. The total average groundwater pumping between April and October was approximately 6,000 af in full supply years (1999-2019, excluding 2015), but increased to over 35,000 af in 2015. While the District does not own or operate any groundwater wells, growers within WCWD are able to pump from privately-owned groundwater wells to augment available water supplies in years of surface water shortage. As described previously, conjunctive management of surface water and groundwater supplies is a key component of WCWD's drought management strategy. The groundwater supplies that growers used in 2015 are directly supported by surface water recharge in years when surface water supplies are sufficient.

Average monthly total diversions and private groundwater pumping are shown in Figure 7-13. The total combined diversions and private groundwater pumping represent the primary sources of irrigation supply in WCWD. Total average diversions and groundwater pumping between April and October were 262,000 af in full supply years (1999-2019, excluding 2015), and 248,000 af in 2015. While diversions decreased with the curtailment in 2015, the total difference in supply was offset by increased groundwater pumping.

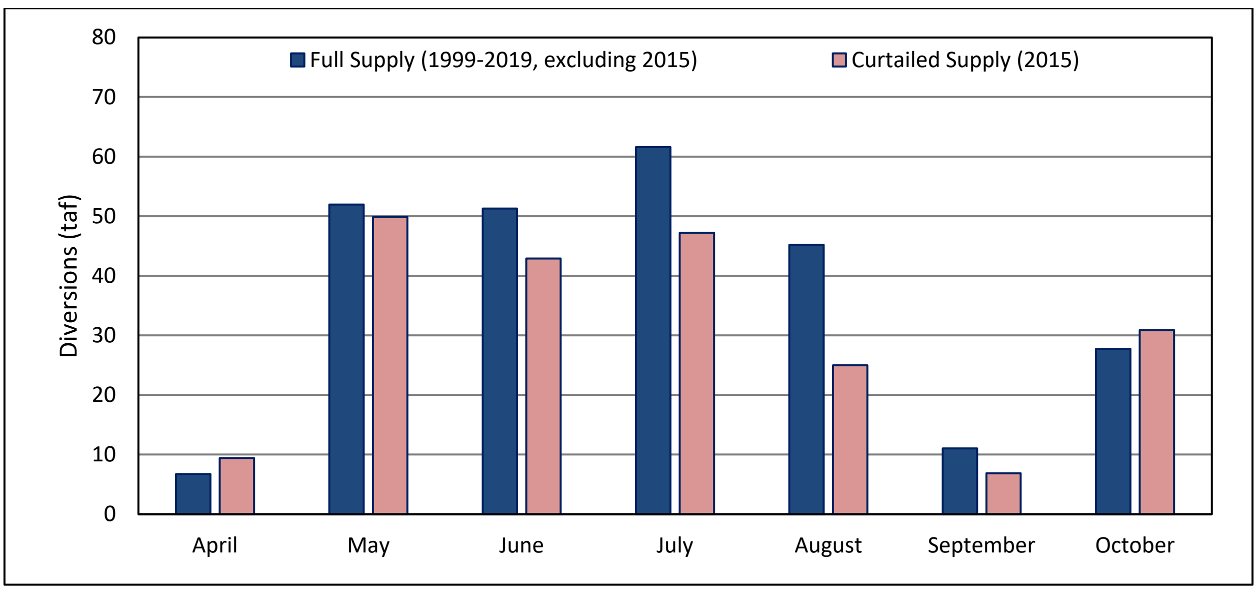

Figure 7-11. WCWD Average Monthly Diversions in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

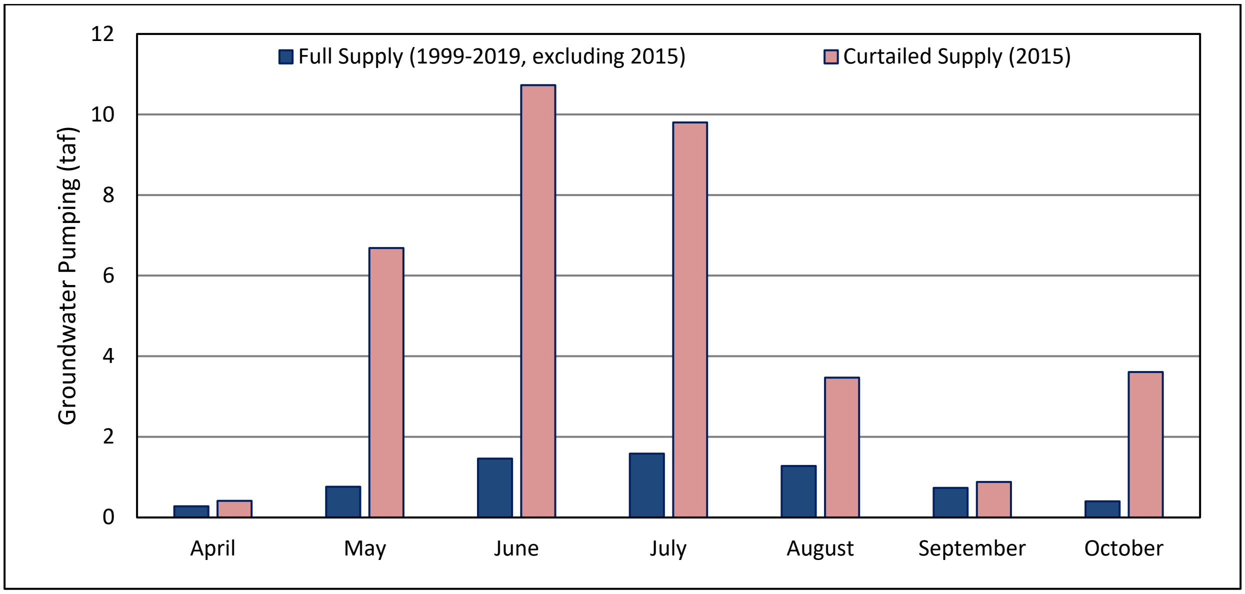

Figure 7-12. WCWD Average Monthly Private Groundwater Pumping in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

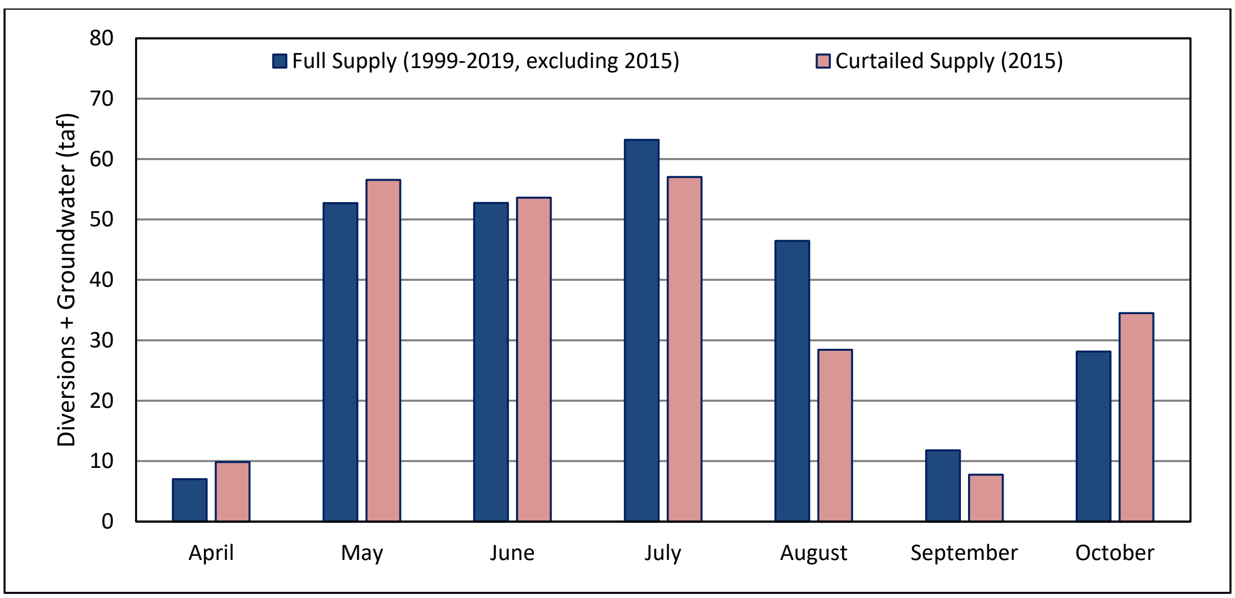

Figure 7-13. WCWD Average Monthly Total Diversions and Private Groundwater Pumping in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

Impacts on Water Demand

To illustrate the impacts of drought on demand in WCWD, applied water demands in 2015 are summarized and compared to demands in other years covered in the WCWD water balance (1999-2019, excluding 2015). The years 1999-2019, excluding 2015, represent years where the full surface water supply was available for diversion by WCWD and demands were fully met. The year

2015 represents a year in which the 150,000 af water supply through the State was curtailed by 50%, representing an overall curtailment of about 25% for WCWD's full surface water supply.

Average monthly deliveries in WCWD are shown in Figure 7-14. In 2015, the deliveries include both surface supplies and comingled private groundwater that is delivered through the District's distribution system. Total average deliveries between April and October were 228,000 af in full supply years (1999-2019, excluding 2015), and 209,000 af in 2015. Deliveries typically represent approximately 80-90 percent of overall diversions, depending on the operational efficiency and drainwater reuse in each year. Deliveries were lower in 2015, corresponding to lower surface water diversions that year. However, as noted in the previous section, the reduction in surface water supplies in 2015 was offset by increased groundwater pumping. Some of this private groundwater pumping comingles with surface water in reaches of the WCWD distribution system where the District has allowed growers to convey groundwater. Including both deliveries and groundwater pumping, the total applied water duty for crops in April to October was similar in 2015 and full supply years, totaling approximately 4.9 af/ac per year. This suggests that WCWD and its growers are resilient to drought conditions. Even in years when surface water supplies are reduced, conjunctive management of surface water and groundwater is effective in sustaining irrigation of cropped land.

Average monthly crop evapotranspiration of applied water (ET_{aw}) in WCWD is shown in Figure 7-15. The total ET_{aw} between April and October was approximately 143,000 af in full supply years (1999-2019, excluding 2015), and 129,000 af in 2015. Dry conditions early in 2015 led to higher applied water demand in the early season, but later in the season ET_{aw} was reduced, particularly in August. This is partly attributable to a reduction in cropped area in 2015, when a total of 47,000 acres were irrigated versus an average of approximately 49,800 acres in full supply years. However, following the curtailment, the cropped area resurged to 51,700 acres in 2016.

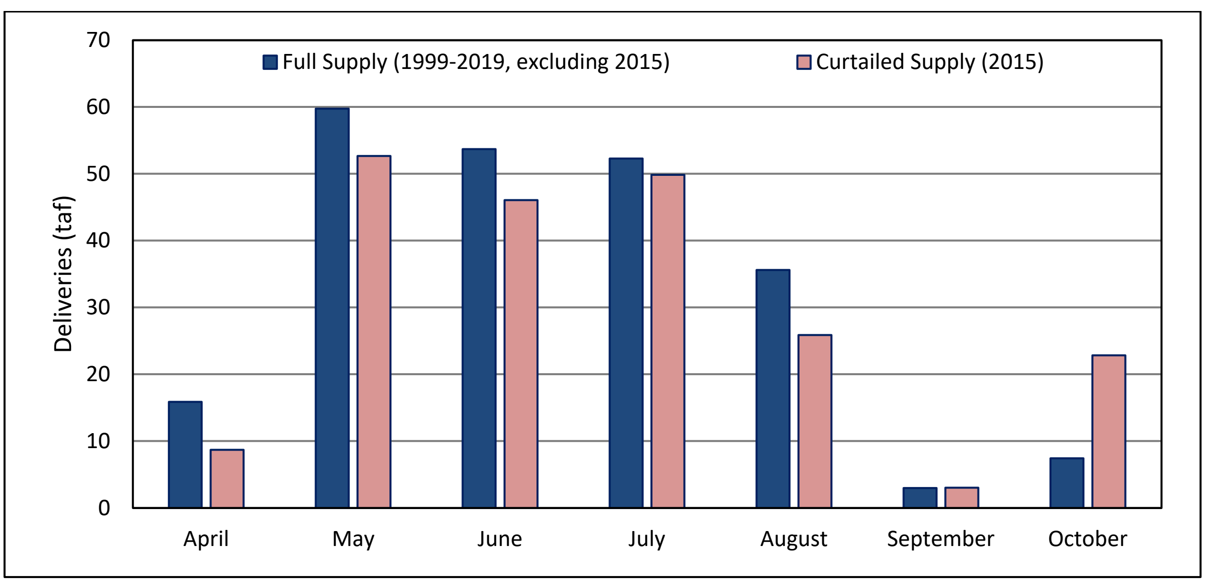

Figure 7-14. WCWD Average Monthly Deliveries in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

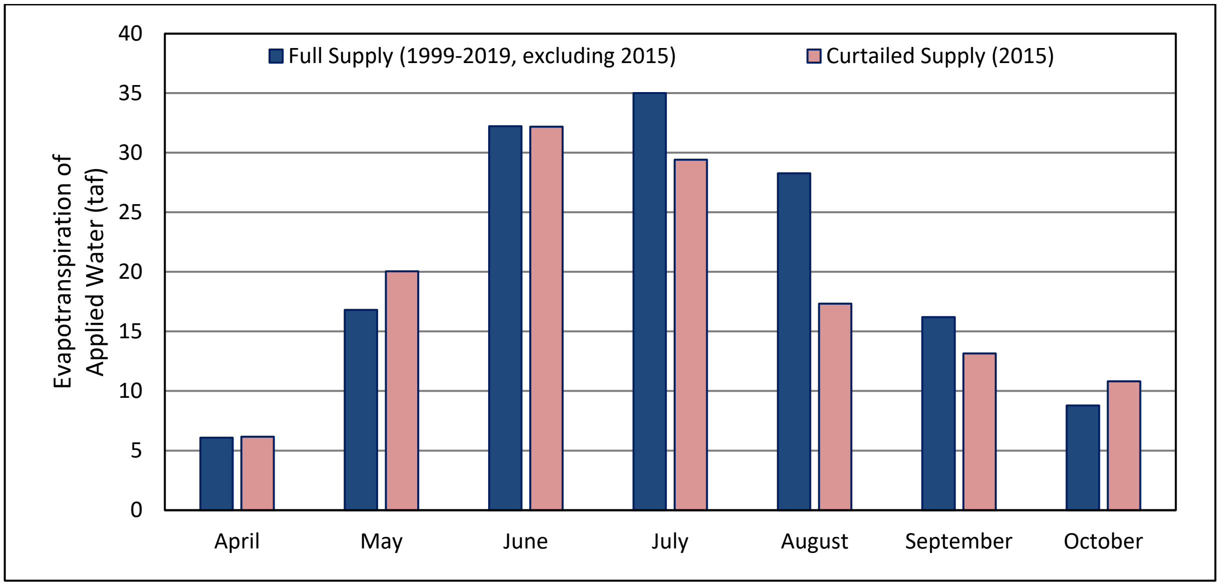

Figure 7-15. WCWD Average Monthly Evapotranspiration of Applied Water in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

Effectiveness of Drought Planning Efforts in 2012-2016

In all, the evaluation of WCWD's water supplies and water demands in 2015 indicate that the District's ongoing drought planning efforts are generally effective in supporting its growers' ability to weather the impacts of drought periods when the District surface water supplies are limited.

As described throughout this plan, WCWD has access to reliable water supplies, totaling at least 295,000 af in full supply years. Since the mid-1990s, the District's supplies were curtailed only in 2015. The District's diversions in 2015 totaled 212,000 af, approximately 17 percent lower than average diversions in full supply years (1999-2019, excluding 2015). When surface water supplies dropped in 2015, growers were able to utilize groundwater supplies available due to ongoing conjunctive management and surface water recharge in WCWD. WCWD's conjunctive management of surface water and groundwater supplies is thus an effective drought resilience and response strategy.

Although groundwater pumping increased during the curtailment in 2015, the total pumping in the following years (2016-2019) returned to levels typical of other, earlier full supply years. Likewise, although the total cropped area and ET_{aw} decreased during the curtailment in 2015, both increased again in 2016 as full supply returned. These temporary shifts suggest that although the severe drought and curtailment in 2015 pushed growers to temporarily pump more groundwater and change their agricultural practices, the availability and affordability of WCWD's surface water supplies strongly incentivize conjunctive management and increased use of surface water when it is available.

These findings indicate that WCWD's ongoing water management and drought planning efforts are effective in sustaining agricultural production even during extended droughts and years when District supplies are curtailed.

References

DWR. 2020. A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2020 Agricultural Water Management Plan. California Department of Water Resources.

Attachments

A. Water Shortage Allocation Policy

B. Surface Water Assignment Form

Attachment A

WESTERN CANAL WATER DISTRICT

WATER SHORTAGE ALLOCATION POLICY

When Western Canal Water District is notified of a water deficiency of 25% pursuant to its contract with the Department of Water Resources (DWR) and/or in the opinion of the Board of Directors of Western Canal Water District there is a water shortage, the water will be apportioned on a pro-rata basis to all primary acreage for which a standby fee is paid. Secondary acreage will not receive any water allocation from the District. Secondary acreage may receive water by assignment pursuant to this policy.

The Board will determine the amount of water to be shared, including water needed to cover system losses and other obligations. The Board will use the preliminary forecast as provided by the DWR on or before February 15 in considering the water allocation. This does not limit the Board in considering other factors, including applications for water, or in amending (increasing or decreasing) the allocation at any time.

The Board's preliminary allocation will be made on March 15. Complete applications for water will be due on or before April 15. Should no application be made at the proper time and in the proper manner, no water will be served, except upon direction of the Board, for that parcel for that irrigation season pursuant to Water Code section 35453.

After receipt of applications, the District will mail out a final water allocation, invoices, and issue notice of rules, rates and policies regarding drought conditions.

1. **Surface Water**
   a. The District will deliver water only to Applicants who have timely and completely filed out an application.
   b. The District reserves the right to increase or decrease the final allocation at any time based on new information or changed circumstances. The District will notify all Applicants concerning any amendments to their allocation.
   c. The District will not supply water in excess of each Applicant's allocation. During the irrigation season, the District will keep track of Applicants' water use and will periodically notify each Applicant of then-current usage and remaining allocation. Failure of the District to provide notice shall not permit Applicant to divert water in excess of their allocation; each Applicant is expected to monitor their diversions to ensure they do not exceed their allocation. The District will cease deliveries once an Applicant's allocation has been met.

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d. Assignments of Surface Water
   i. Upon notice to the District, any Applicant may assign all or a portion of their surface water allocation to different fields within the District that are owned or leased by the same Applicant.
   ii. Applicants may assign all or a portion of their surface water allocation to another landowner/grower within the District, provided:
      1. The Applicant and the assignee complete a District assignment form and pay for the water in advance, including a one-time administration/wheeling charge of $200.
      2. Completed assignment forms may be approved by the General Manager at any time. If the General Manager denies a request for assignment or, due to unique circumstances, is unwilling to approve or deny the request, the assigning landowner may seek reconsideration by the Board of Directors. Requests for reconsideration must be received by the District office on or before the Wednesday before the District's regular board meeting (the third Tuesday of each month) so the item may be placed on the agenda for consideration by the Board of Directors.
      3. The District reserves the right to deny assignment requests for any reason, including without limitation inadequate capacity to wheel the water through the District's facilities.

2. Groundwater

a. The District will not allow the use of its facilities to wheel or accommodate the transfer or assignment of groundwater that may be pumped by landowners. Upon application, a landowner may be allowed to utilize District facilities to convey groundwater to the same landowner's fields. The District reserves the right to grant or deny such request for any reason.

3. Out of District Assignments

a. Upon request, the Board of Directors of the District will consider assignments of any Applicant's surface water allocation to any Joint District. Prior to making the request, the Applicant must first have obtained the written consent of the applicable Joint District to the possible assignment. Notwithstanding the consent of the applicable Joint District, the District reserves the right to grant or deny any out of district assignment for any reason.
b. The District will not permit out of District assignments to entities or individuals outside the Joint Districts.

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Attachment B

WESTERN CANAL WATER DISTRICT

SURFACE WATER ASSIGNMENT FORM

This Surface Water Assignment Form is made and entered into on the date last shown below, with reference to the following facts:

A. Due to severe reduction of its available water supply in 2014, Western Canal Water District ("District") has authorized, in accordance with Water Code Sections 35420 and 35421, an allocation of water during the irrigation season, from April 1 to September 30, to each applying landowner and has further authorized the assignment of an applying landowner's allocation to another landowner in the District.

B. ______________________________("Assignor") is a landowner entitled to an allocation of water within District and is willing to assign a portion of his/her/its surface water supply to Assignee in 2014.

C. ______________________________("Assignee") is a landowner entitled to an allocation of water within District and is requesting assignment of all or a portion of Assignor's surface water supply in 2014 .

D. Subject to District's approval, Assignor agrees to assign to Assignee _____________ acre-feet for reasonable and beneficial use on Assignee's lands within Western Canal Water District in the 2014 irrigation season.

E. Assignor and Assignee agree that the District, in its sole and absolute discretion, may deny the assignment request. In addition, Assignor and Assignee agree, on the basis of good and valuable consideration, to the following terms and conditions governing the assignment:

1. **Payment to District.** Payment by Assignor for the water to be assigned must be delivered to the District along with a fully completed Assignment Form. District is entitled to full payment for all water assigned, whether or not the assigned water is fully used by Assignee. District's regular rate for water will apply to the water assigned. In addition, a one-time District administrative fee of $200 will also be paid to the District. If the District denies the assignment request, the District will refund payments made under this Article 1.
2. **Payments Between Assignor and Assignee.** Payments, if any, between Assignee and Assignor are the exclusive responsibility of those parties and are not addressed by this Assignment Form. The District will not monitor, ensure payment, or otherwise have any responsibility concerning any parties' compliance with the business terms of the assignment.
3. **Amendments**. Upon completion of the Form and approval of the assignment by the District, the assignment is final and may not be withdrawn, amended, or terminated. No assigned water may be reassigned.
4. **Water Shortage Allocation Policy.** Assignor and Assignee have reviewed and agree to abide by the District's Water Shortage Allocation Policy and any potential amendments thereto. Assignor and Assignee understand and acknowledge that the District may increase or decrease final allocations at any time based on new information or changed circumstances.
5. **Other District Rules.** Assignor and Assignee agree to abide by the District's other rules and regulations concerning the use of water within the District and any amendments thereto.

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6. **<u>Hold Harmless, Indemnity, Defense</u>.** Assignor and Assignee, jointly and severally, agree to defend, indemnify, and hold harmless District, its officers, employees, and consultants from and against any and all claims, liabilities, costs, damages (including attorneys' fees and court costs), lawsuits, or other actions or proceedings (collectively "Claims") arising out of or related to this Assignment Form, its implementation, or the assignment of water between Assignor and Assignee. Without limiting the generality of the foregoing, this Article 6 specifically applies to Claims (1) by or between Assignor and Assignee; (2) initiated by a third-party(ies) objecting to or asserting Claims related to the assignment; and (3) against District for declaratory or injunctive relief, including without limitation, Claims lodged against the District under the California Environmental Quality Act.
7. **<u>Signature Authority</u>.** Assignor and Assignee represent and warrant they are authorized to sign this Form and to act on behalf of any applicable corporation, partnership, trust, or other business or legal entity that may own an interest in either Assignor's or Assignee's real property.

"ASSIGNOR"	**"ASSIGNEE"**
___________________________	_________________________________
Date:_____________________	Date:_____________________________

Western Canal Water District approves this assignment.

____

Date:_____________________

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